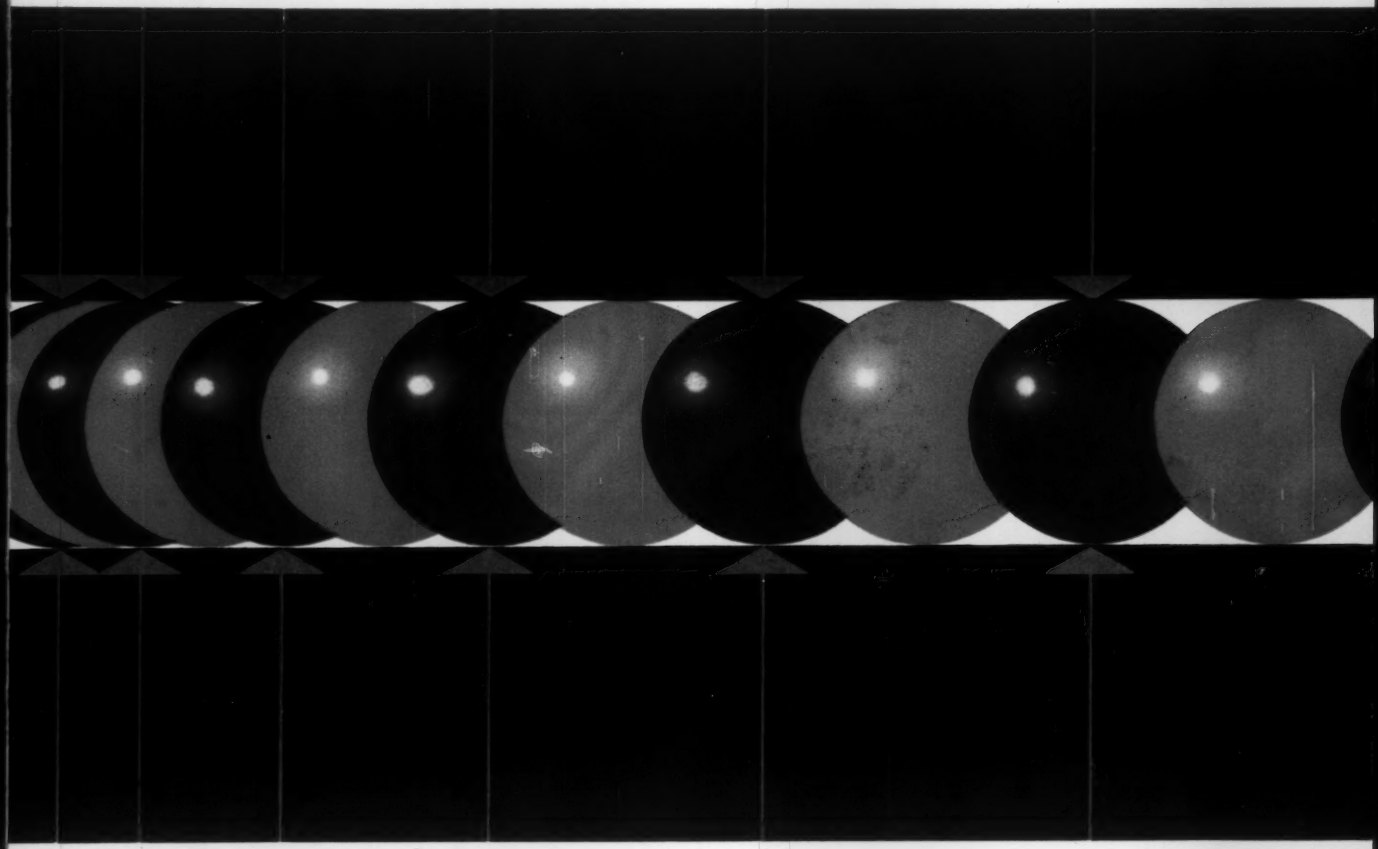
AUGUST 7, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Plastic Ball and Roller Bearings

Contents, Page 3

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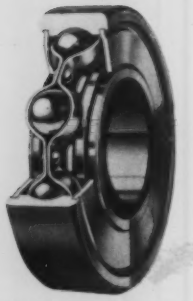
NORMA-HOFFMANN

precision NH *bearings*

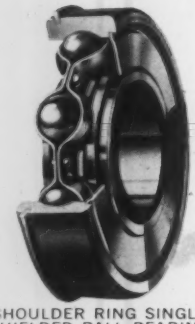
FOR EVERY LOAD, SPEED AND DUTY OVER 100 DISTINCT SERIES

SIZE RANGE ⅛" TO 21" BORE--METRIC AND INCH

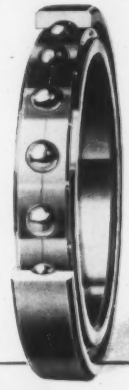
Write for catalog and engineering assistance



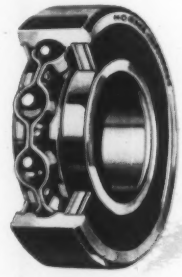
DOUBLE SHIELDED BALL BEARING



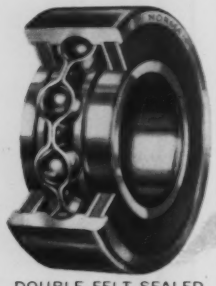
SHOULDER RING SINGLE SHIELDED BALL BEARING



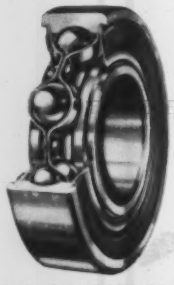
EXTRA LIGHT BALL BEARING



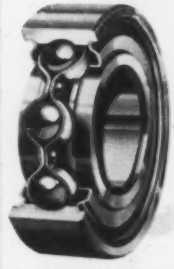
FELT SEALED AND SHIELDED BALL BEARING



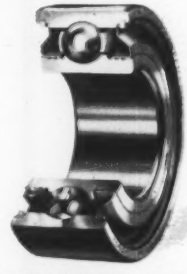
DOUBLE FELT SEALED BALL BEARING



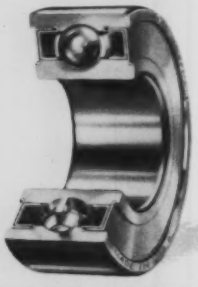
DOUBLE RUBBER SEALED BALL BEARING



DOUBLE METAL SEALED BALL BEARING

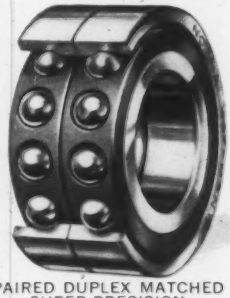


"CARTRIDGE" BALL BEARING WITH REMOVABLE SEALS



"CARTRIDGE" BALL BEARING WITH FLINGER SEALS

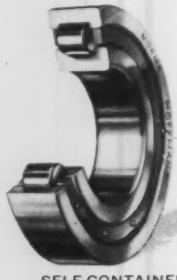
AIRCRAFT CONTROL FULL TYPE RUBBER SEALED BALL BEARING



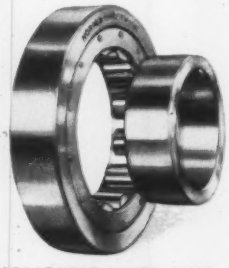
PAIRED DUPLEX MATCHED SUPER-PRECISION BALL BEARINGS

BALL THRUST BEARING

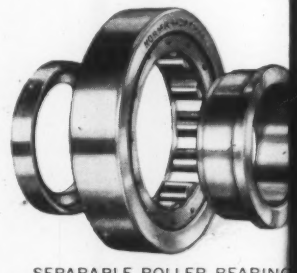
SEPARABLE OUTER RING ROLLER BEARING



SELF-CONTAINED ROLLER BEARING



SEPARABLE INNER RING ROLLER BEARING



SEPARABLE ROLLER BEARING WITH EXTRA THRUST RING

NORMA-HOFFMANN BEARINGS CORPORATION / STAMFORD, CONNECTICUT

founded in 1911

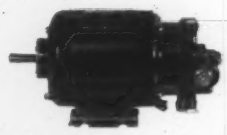
FIELD OFFICES: PHILADELPHIA • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • KANSAS CITY • LOS ANGELES • SAN FRANCISCO • SEATTLE

Circle 401 on Page 19

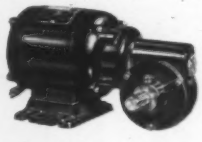
Combine your motor and speed reducer in one unit
Save space . . . eliminate cumbersome belts, chains, gears
Reduce design and installation time

with BODINE SPEED REDUCER MOTORS

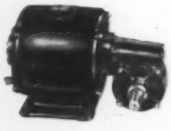
Bodine manufactures the world's most complete line of speed reducer motors in the sub-fractional horsepower range. Speeds down to 0.6 rpm. Torques up to 350 in. lbs. Here's part of the Bodine Speed Reducer Motor line:



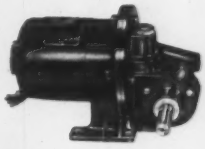
. . . single or double reduction reducer for transmitting low torques over a wide range of speeds. The worm is of long wearing nitralloy steel (except for low-powered V-10R and NSP-11R); the gear of laminated bakelite, giving quietness and durability. Motor shaft equipped with ball or sleeve bearings. Speeds from 833 to 1.5 rpm. Torques 12.8 in. oz. to 8 in. lbs.



. . . single reduction, right angle worm gear reducer designed for transmitting moderate torques, Separable hardened and ground steel worm. driven by keyway on end. Laminated bakelite gear on steel hub gives maximum wear and quietness. Speeds from 500 to 29 rpm. Torques 4.5 to 21 in. lbs.



. . . sturdy, single reduction, right angle worm gear reducer, capable of transmitting substantial torques. It has a separable hardened and ground steel worm. Gears of laminated bakelite or hard gear bronze, depending on torque delivered. Grease is used with all bakelite gears; oil with bronze gears. Speeds from 500 to 29 rpm. Torques 11 to 73 in. lbs.



. . . double-worm-gear speed reducer to deliver moderate torques at low speeds. Both primary and secondary worms are of nitralloy steel. Laminated bakelite primary gear assures long wear and quietness; the hard bronze secondary gear carries substantial torque loads. Speeds from 83 to 1.6 rpm. Torques 13 to 52 in. lbs.

. . . double worm gear reducer for transmitting high torques at low speeds. Worms accurately ground from hardened steel; bakelite primary gear assures quietness; hard bronze secondary gear provides long life. Speeds from 24 to 5.7 rpm. Torques 88 to 219 in. lbs.

. . . heavy duty reducer for driving heavy loads continuously with an ample reserve for overloads. Separable steel worms are hardened and ground to size. Gear bronze, selected for strength, is cut by special hobs to close tolerances. Speeds from 173 to 36 rpm. Torques 50 to 198 in. lbs.

Write for technical bulletin 1022B. Twelve pages of facts and figures . . . 33 photos, drawings, curves, and tables tell the complete story of Bodine Worm Gear Speed Reducer Motors. For details of smaller Bodine spur-gear speed reducer motors, ask for bulletin 1023.

BODINE ELECTRIC CO., 2258 W. OHIO ST., CHICAGO 12

BODINE
fractional / horsepower
MOTORS

BODINE ...the power behind the leading products

...2nd of series

How to make motors last longer

Fractional horsepower electric motors, given proper maintenance, will operate without trouble for long periods of time. Here are a few maintenance suggestions:

Check internal switches. While internal switches usually give little trouble, regular attention will make them last even longer. Use fine sandpaper to clean contacts. Be sure sliding member on shaft moves freely. Check for loose screws.

Watch alignment. A motor shaft which is out of line with its load will cause the shaft and bearing to wear rapidly, sometimes damaging the driven machine.

Provide adequate wiring. Be sure that wire of proper size is used to feed electrical power to your motor. If necessary replace wire. It will prevent overheating, reduce your electric power cost, and in many instances prevent future breakdown.

Provide adequate lubrication. Remember, a motor running three times as much as usual will need three times as much attention to lubrication. Provide enough oil, but don't drown your motor. See manufacturer's recommendations.

Watch future Bodine ads for more maintenance tips.

Free chart tells how to locate motor troubles

"Common Motor Troubles and Their Causes" is the title of a 1-page bulletin and chart which will help you diagnose ailments of small motors. It lists troubles and probable causes. Copies are available on request.

Circle 404 on Page 19

Now you can get standard sizes in C/R End Face Seals!

Chicago Rawhide now announces the availability of a complete new line of Standard End Face Seals to meet the widest possible range of sealing requirements. For sizes or conditions beyond the range of Standard End Face Seals, C/R engineers will continue to cooperate with you on special designs. Their experience in sealing applications is unmatched — your assurance of getting the correct seal for the job.

Write for your free copy of this new C/R Bulletin →

Bulletin EF-100 includes complete envelope space data on C/R Standard End Face Seals and mating rings to help you select the correct size for your equipment design:

- Size range table in two series — long and short — from ¾ to 4 inch shaft diameter.
- Size range table on mating rings.
- Typical seal installations for internal and external pressure.
- Special instructions on how to order.

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STANDARD
END FACE SEALS
maximum sealing efficiency in minimum space
¾ to 4 inch shaft sizes
pressures to 500 psi.
temperatures to 500° F.
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external or internal pressures
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C/R OIL SEAL DIVISION

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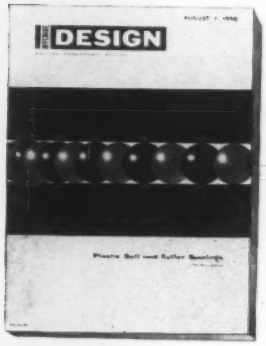
C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-Metallic Gears

Circle 405 on Page 19



Front Cover: Alternate plastic balls bear the load and intermediate balls serve as spacers in artist George Farnsworth's side view of a thrust bearing used on tanks. Featured article is by Joseph E. Montalbano on Page 96.

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Report Satellite Findings

Data on Outer Space Deviate from Theory

WASHINGTON — Preliminary reports on data gathered by U. S.-IGY satellites 1958 Alpha (Explorer I) and 1958 Gamma (Explorer III) were presented recently before a special meeting at the National Academy of Sciences. The reports discussed high-intensity radiation, micrometeorites, satellite temperatures, and atmospheric densities.

High-intensity radiation was encountered at altitudes above 1000 km. This radiation was so intense as to exceed design capabilities of the electronic systems for either direct transmission or for stored and played-back transmission. But the approximate intensity was determined by a detailed study of the data and by laboratory calibration of the over-all electronic system. It is estimated that for portions of the orbits of 1958 Alpha and 1958 Gamma, a Geiger tube of zero dead time would produce over 35,000 counts per sec, or on the order of 1000 times the cosmic ray rate.

This radiation is thought to be very closely related to auroras and geomagnetic storms. A rough calculation suggests it may be sufficiently intense to contribute important heating to the upper atmosphere. Consequences of the radiation in the production of atmospheric ionization, light, and radio noise are being investigated.

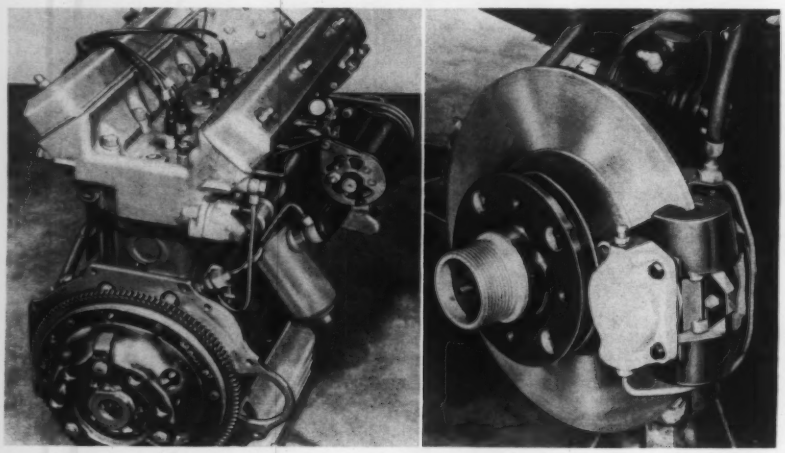
Optical studies of 1958 Alpha, which was spun about its long axis during launching, show it later appeared to rotate about its short axis, propellerlike. This conclusion is based on observed variation of orbital acceleration. A simplified formula for computing the air density at very high altitudes from the motion of artificial satellites gives an air density value of about 1.5×10^{-14} gm/cm^3 at an altitude of 368 km. A cubic mile of air of this density would weigh only 2 oz. Nevertheless, the density is about 15 times greater than had been predicted.

Orbital determinations were difficult to make. However, preliminary estimates by the Naval Research Laboratory indicate the lifetime of 1958 Alpha will be about 5 to 10 years.

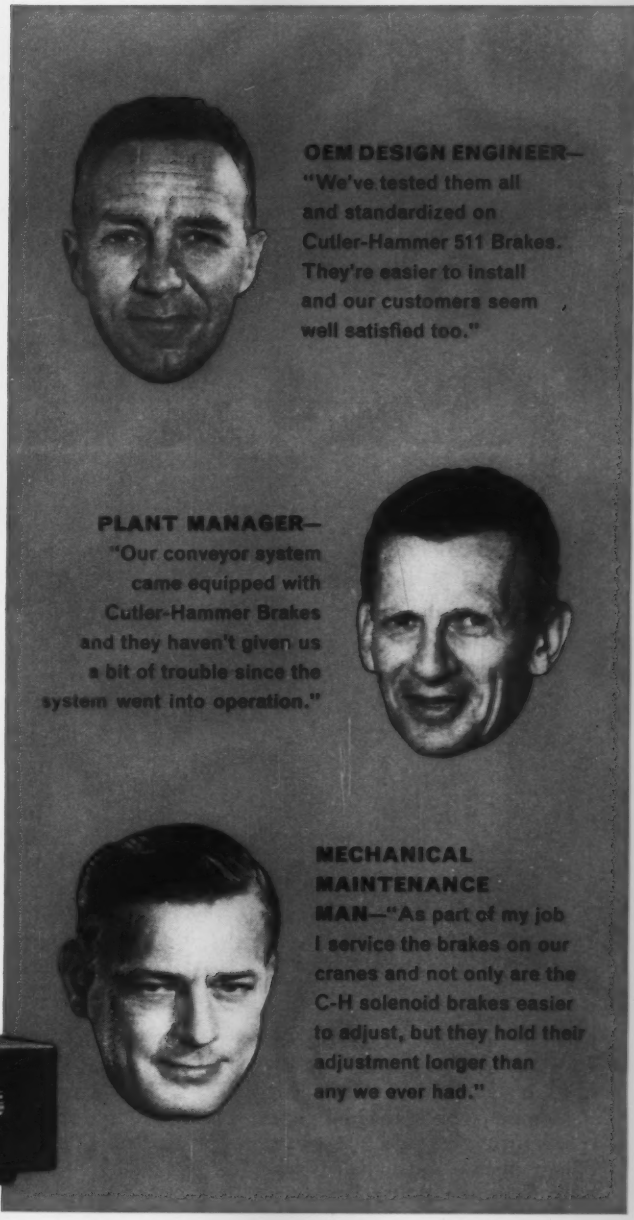
Temperature measurements made by 1958 Alpha show internal temperatures ranged from 0 to 35 C inside the cylinder and from 5 to 40 C inside the nose cone. Shell temperatures ranging from −25 to 75 C were recorded.

The temperature-control mechanism consists of a series of aluminum oxide stripes covering approximately 25 per cent of the outer surface of the cylindrical section of the instrument compartment, and 30 per cent of the outer surface of the nose cone. By both reflecting and reradiating heat received from the sun and the earth, this coating maintained interior temperatures

MG COMPETITION CAR, with a top speed in excess of 120 mph, is powered by a twin camshaft version of the MGA engine. The new powerplant delivers 107 hp at 6500 rpm, versus 68 hp at 5400 rpm for the original engine. Bore and stroke are 2.9 x 3.5 in., displacement is 96.9 cu in., and comp ratio is 9.9 to 1. The new model accelerates from 0 to 110 mph in 38 seconds; has disc brakes on all four wheels. Photos below show the new twin overhead camshaft engine, left, and brake disc assembly behind the threaded knock-on wheel mount, right.



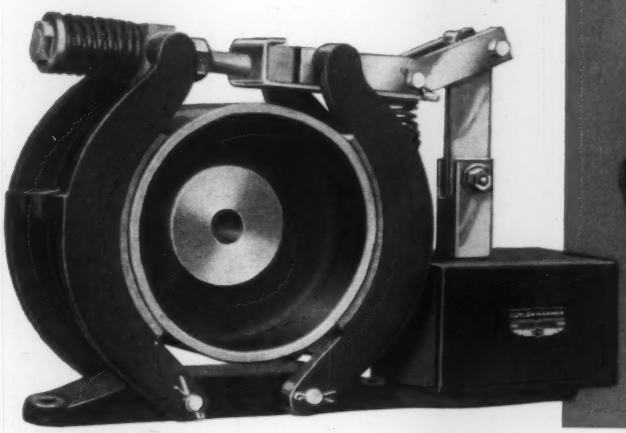
THREE
good reasons why
Cutler-Hammer 511 brakes are preferred throughout industry



OEM DESIGN ENGINEER— "We've tested them all and standardized on Cutler-Hammer 511 Brakes. They're easier to install and our customers seem well satisfied too."

PLANT MANAGER— "Our conveyor system came equipped with Cutler-Hammer Brakes and they haven't given us a bit of trouble since the system went into operation."

MECHANICAL MAINTENANCE MAN— "As part of my job I service the brakes on our cranes and not only are the C-H solenoid brakes easier to adjust, but they hold their adjustment longer than any we ever had."



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CONTROL
C·H

You, too, will find it pays to specify and install Cutler-Hammer 511 Solenoid Brakes. Available for either A-c or D-c service, Cutler-Hammer 511 Solenoid Brakes are rated from 3 to 125 lbs. ft. torque continuous duty and 3 to 160 lbs. ft. torque intermittent duty. Write today for Bulletin 511-Q243 for complete description, ratings, optional features, and dimensions. CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.

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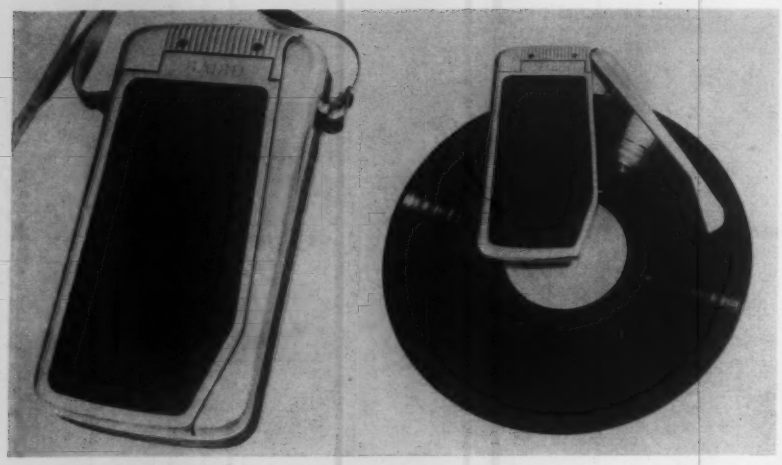


POCKET-SIZE RECORD PLAYER has no turntable. The tone arm is part of the lid. It plays any size of 33 1/3 and 45-rpm record, is battery-powered, and self-contained with low-drain motor, transistorized amplifier, and loudspeaker. In spite of eventual battery rundown, a unique governor maintains constant record speed. Two rubber-tipped shafts replace the usual turntable. The entire assembly is 8 in. by 4 in. and 1 in. high. The unit was developed by Camp Bird Ltd., of London, England.

within the range needed to protect instrumentation from damage by heat or cold.

The experiment was designed only to study the problem of controlling instrument environment in a very small enclosure. However, it was noted that this technique provided temperature control in a satellite within the range of human survival.

Micrometeorite densities were recorded by two detection systems. One, called the gage detector was installed on both 1958 Alpha and 1958 Gamma. The individual gages are 1 sq cm in area and are wound with two layers of enameled wire 17 microns in diameter. Twelve of these gages, covering an area of 2 sq in., are mounted in a circular pattern flush with the surface of the satellite's midsection. When a micrometeorite of 5 to 10-microns diameter and traveling at meteor velocities, on the order of 25,000 mph, smashes into one of the gages, the continuous circuit breaks and changes the transmitted signal.

The second detector flown only on 1958 Alpha, consists of a crystal microphone mounted against the skin of the satellite and connected to an amplifier. When the satellite is struck by a solid particle, the impact pressure is converted into an electrical signal which is transmitted to the monitor stations.

About 10 per cent of the microphone data and 50 per cent of the gage data from 1958 Alpha have been available for study. Seven hits have been detected by the microphone on 1958 Alpha, but after 32 days of flight only one gage had registered an impact. These data indicate that average influx of particles 10 microns in diameter or greater was not more than 10^{-3}/m^2/sec during the period of observation, and that the average influx of particles 4 or more microns in diameter was about $10^{-2}/m^2/sec$.

Equalizing longevity of light bulbs is a new task assigned to electronic computers. Experiments are being conducted at GE's Lamp Div. with a Bendix Aviation Corp. G-15 computer, which has been adapted to help solve radiation problems involving temperature changes in wire filaments and filament vibration. These two factors are important in the life of a light bulb. Determining why bulbs of identical quality or similar manufacture show marked differences in life and correcting this nonuniformity should result in reduced electricity consumption and fewer bulb replacements.

Topics

Nonsupernatural vibrations call a person to the telephone in a new electronic paging system in use at the AC Spark Plug plant. The Vibacall system signals by causing a small, pocket-toted radio receiver to vibrate for a few seconds, thereby sending the radio's carrier to the nearest telephone to receive his message. Paging equipment consists of a master console, remote booster amplifiers, and as many as 380 personal pocket receivers.

• • •

Matriculating mill has left for Syracuse University from the Weirton Steel Div. plant of National Steel Corp., Weirton, W. Va. Donated to the university's metallurgical research laboratory, the 25-ton mill will roll uranium, titanium, and super-high-strength steels. Its primary use will be in research to improve the quality of rolled strip steel.

• • •

First space man of letters has received his doctorate in space navigation. Dr. Robert M. L. Baker, the first graduate of the only space navigation program in the U. S., has been awarded a Ph.D. from UCLA.

• • •

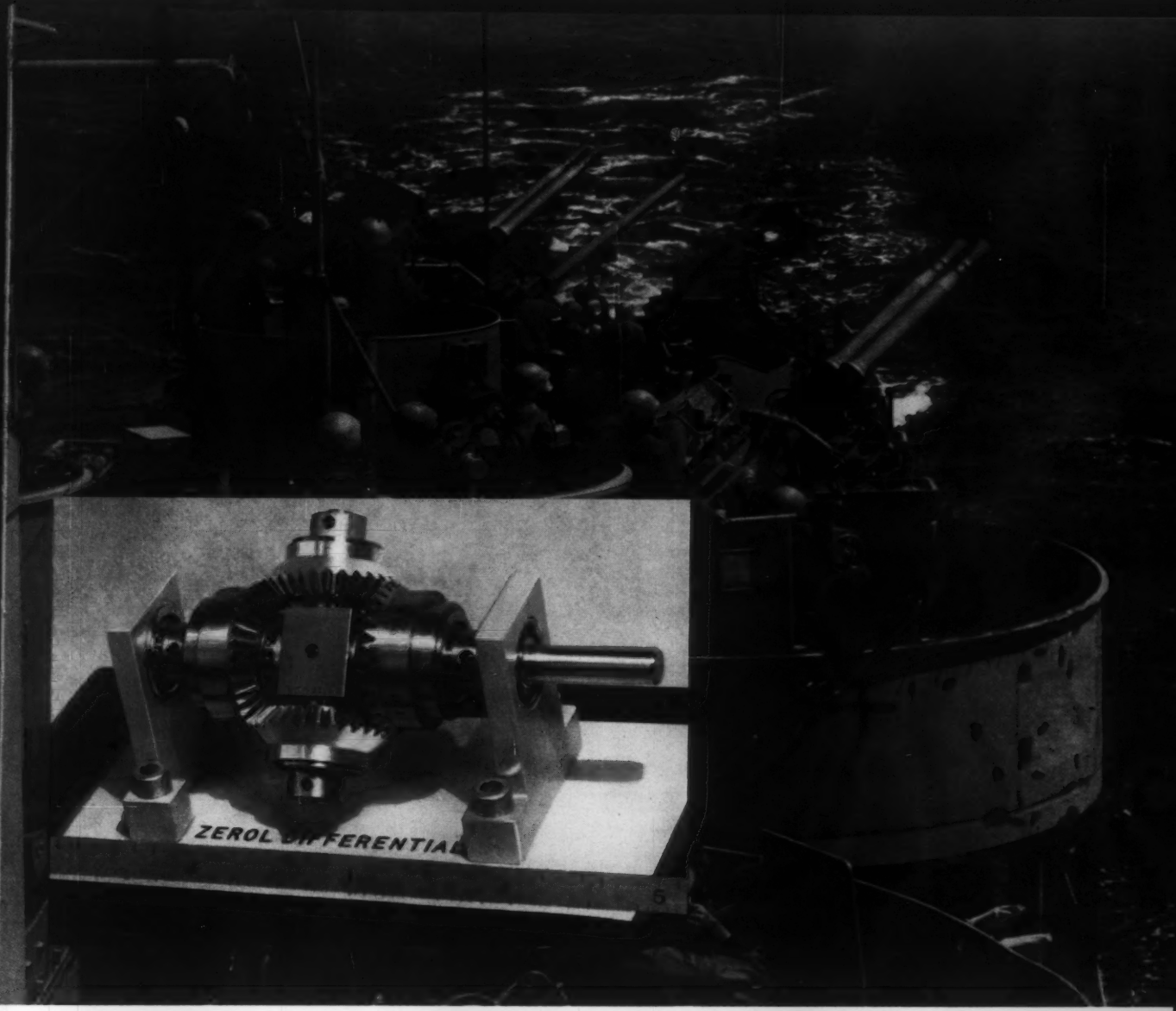
Kiddie cutlass, a recently patented invention described as "an amusement device or toy," is a knife rigged with a length of tubing which carries a red fluid to the tip. The fluid, stored in the toy weapon's handle, is released by the wielder when contact is made with the blade, simulating bleeding so that, according to the patent, "the device can be used with increased pleasure due to the realistic effect created."

• • •

Steam au naturel, direct from geysers, will produce electric power. Pacific Gas & Electric Co. plans to construct a 12,500-kw generating plant to produce electric power from geyser steam near Sonoma, Calif., about 40 miles north of San Francisco. Steam will be carried in pipes to a turbine, and electricity generated will be transmitted to the power company's central pool.

• • •

It's a train—it's a plane—at any rate it's a possibility that Pennsylvania Railroad passengers will someday travel between New York and Washington in a train powered by a Curtiss-Wright turbo-compound aircraft engine. This proposed hybrid of the transportation family theoretically would shave some 20 per cent off the present minimum New York to Washington travel time of three hours and 25 minutes. The engine's reversible - pitch propeller would accelerate and decelerate the train, reportedly permitting acceleration from 0 to 115 mph in 7000 ft.



Official United States Navy Photograph

When your fine pitch gears *must be accurate*

When you work with fine pitch gears like those in this naval fire control unit differential, tolerances are critical.

Tooth-to-tooth accuracy is extremely important to permit the guns to be sighted precisely on target.

So where accuracy is really critical in the gears you make, Gleason can help you three ways:

1. Machines that cut or grind any fine pitch gear

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2. Machines that test gears thoroughly

The Gleason No. 104 Hypoid Tester, for example, checks running qualities, tooth spacing, and concentricity of gears. It records test results on paper so that you have a permanent record of the total tooth-to-tooth composite error.

3. Engineering services

Gleason engineers are ready at all times to help you with any phase of the design and manufacture of fine pitch gears.

Simply write or phone for prompt assistance on any of your fine pitch gear requirements.

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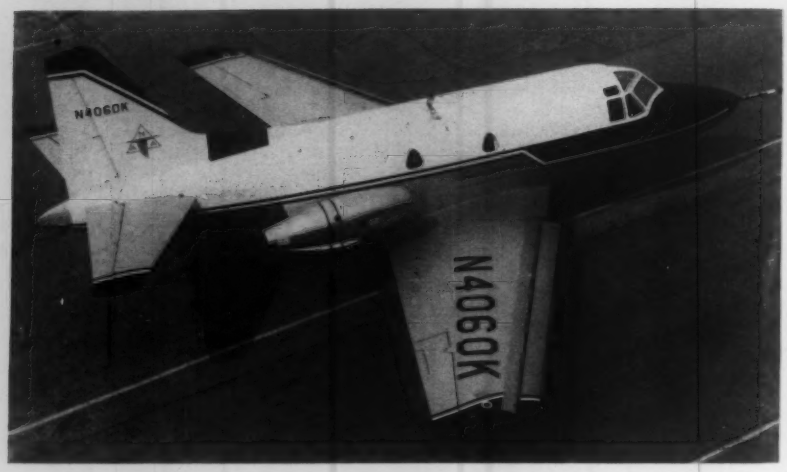
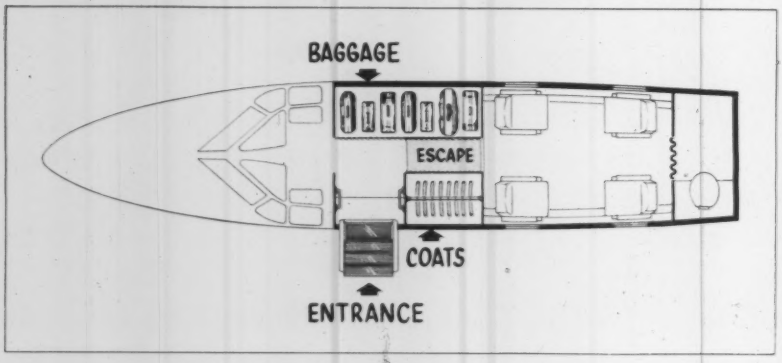


SAFE AND VERSATILE, North American's new twinjet Sabreliner fills USAF need for a utility jet trainer and transport. It also meets CAA requirements. The new jet carries a crew of 2 plus 8 passengers or 2500 lb of cargo and training devices. Cruise altitude is 41,000 ft; maximum speed, 575 mph. Safety features include extra-wide windshield—an SAE recommendation—and a big hydraulic speed brake that causes no trim change when opened. Bailout hatch in the cabin floor opens behind speed brake, which acts as a wind deflector. Sabreliner will operate at 1/3 the cost per nautical mile as a prop-driven C-47 or B-25 bomber.



Fifth Mechanisms Conference To Have Varied Program

Two-Day Meeting Drew 285 Engineers Last Year

CLEVELAND, O. — A varied program is scheduled for the Fifth Conference on Mechanisms to be held October 13 and 14. Co-sponsored by MACHINE DESIGN and the School of Mechanical Engineering, Purdue University, the Conference will be held on Purdue's campus in West Lafayette, Ind.

Topics in this year's program of more than 12 papers include cam design, linkage design, space mechanisms, computing mechanisms, and measurement as a tool in mechanism design. Traditionally, the papers are authored and presented by leading authorities in mechanism design.

Social highlights of the two-day meeting are a banquet on October 13 and a luncheon October 14.

The Conference is probably the only one of its type in this country and provides a unique opportunity for exchange of information and ideas on mechanism design. It is open to attendance.

Cost of the social affairs and a copy of the conference transactions is included in the $35.00 registration fee. Registration, travel, and housing details will appear in future issues of MACHINE DESIGN.

Army's Electronic Earphone Quiets Ambient Noise

Jet Whine and Tank Rumble Muffled to Whisper Level

WASHINGTON—Quiet is artificial, but effective, when listening through a new electronic earphone developed by U. S. Army Signal R & D Laboratory, Ft. Monmouth. The new device is considered to be a major breakthrough in noise reduction.

A miniature microphone contained in the earpiece creates a noise equal in volume, but opposite in phase, to ambient noise. Total noise level is muffled to a whisper. Low pitched sounds are reduced to as little as 1/10 their original volume, higher pitched sounds are trapped by special foam cushioning.

The new earphones, first of their kind, are expected to have many commercial as well as military uses. They could be worn by riveters and mill workers, for instance, where the roar of machinery is not only a nuisance, but sometimes a menace.

In combat, the earphones might be used by artillerymen to protect their eardrums and improve communications, or could increase the efficiency of sonar operators by eliminating distracting noises. They might also quiet high noise levels for jet bomber maintenance crews.

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Kit-Built Gyrocopters— Future Aerial Runabouts?

CAA Is Uneasy Observer Of Wingless High-Flyers

RALEIGH, N. C.—Easy to assemble and easier to fly, do-it-yourself gyrocopters made by Bensen Aircraft Corp., Raleigh, N. C., are stirring up more than air. Export models of the aerial runabout are flying in all parts of the world, but getting one off the ground in the U. S. requires more than takeoff procedure. Inspection by the CAA is a necessary requisite, and this agency apparently has no desire to see a flying machine in every garage. Bensen's latest one-man craft, for example, won't rate a license if bought preassembled from the factory because its 72-hp engine doesn't have dual ignition. For the cost of tooling, one engine manufacturer would gladly supply engines with an additional sparkplug hole drilled in the cylinder head, but according to Bensen, this might not be the final CAA requirement.

In the meantime, many die-hard copter fans in this country are flying home assembled machines under an experimental arrangement. The CAA will license an experimental craft if it is airworthy. Plans and parts supplied by several manufacturers, including Bensen, meet this requirement. A variety of engines can be matched to the airframe and the builder has, in effect, put together a kit aircraft, although engine and airframe didn't come as one kit.

The CAA's position is understandable. Low cost of some do-it-yourself machines would help create a substantial increase in air traffic, and performance of some of the craft is remarkable. Bensen's 72-hp model will climb 2000 fpm and soar to an altitude of 16,000 ft. It has a maximum speed of 85 mph. According to one CAA official, white lines and stop signs can't be painted in air.

Latest model of Bensen Aircraft's do-it-yourself gyrocopter is powered by a four-cylinder, 72-hp engine. Rate of climb is 2000 fpm, maximum speed is 85 mph. The craft weighs 250 lb and will lift 250 lb.

Metals Matters

Very high purity tantalum metal is produced commercially by National Research Corp., Cambridge, Mass. High purity facilitates melting and fabrication of the new alloy; "unusual" ductility and low hardness (60-65 Brinell) permit reduction of a 3-in. diam ingot to 0.0005-in. foil without intermediate annealing. Large ingots, weighing over 100 lb, can be made into large-size sheet and plate.

Research leading to production of the new tantalum also resulted in development of a new type of vacuum arc-melting furnace to convert tantalum powder to large, high-density ingots. High-purity powder permitted successful arc-melting.

• • •

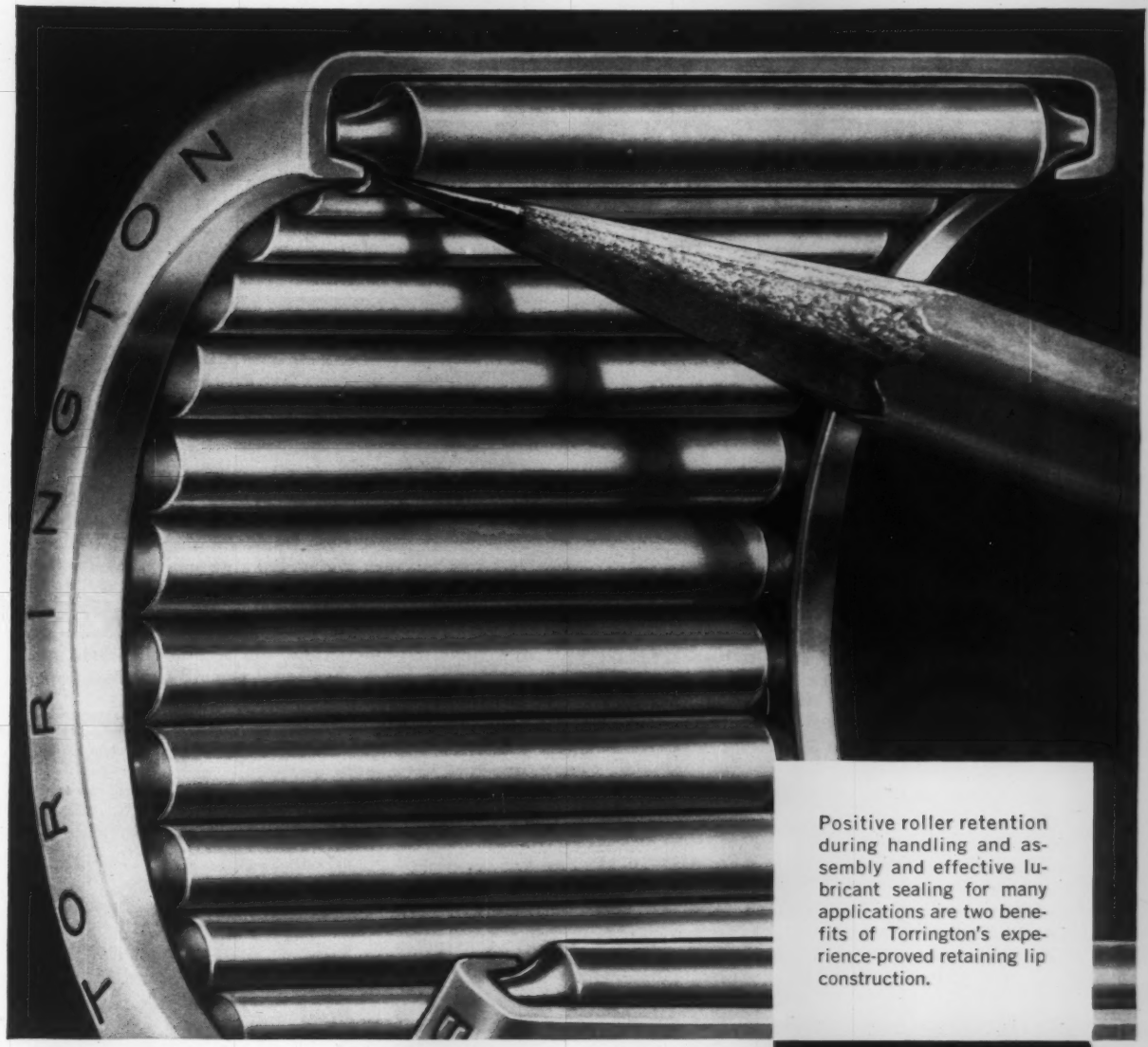
Aluminum is bonded to iron by diecasting in a process for joining automobile wheels and brake-drum linings. Doehler-Jarvis Div. of National Lead Co., Toledo, Ohio, has developed a technique for mechanically bonding diecast aluminum wheels to gray-iron brake-drum liners. Designated B.M.I. for bi-metallic interlock, the new bond is made by inserting a centrifugally cast gray-iron brake-drum liner into the die cavity of a diecasting machine and injecting molten aluminum under pressures of 6000 to 10,000 psi to simultaneously form the wheel and bond it to the brake liner. Heat-transfer efficiency in braking action is said to be increased greatly over that of standard wheels.

• • •

High-temperature metal, a nickel-base, titanium-aluminum hardened alloy can be used in applications to 1800 F. Rene 41, developed jointly by the General Electric Jet Engine and Flight Propulsion Laboratory departments at Evendale, Ohio, is suitable for use in severely stressed jet engine components. It can be formed, welded and machined with comparative ease; it can be inert-arc welded with or without filler material and produces strong, ductile spot welds. The fact that the new metal is one of the strongest materials that can be successfully formed and welded suggests its use for high-temperature bolting and fastener material as well as afterburner parts, turbine casings, nozzle diaphragm partitions and combustion liners.

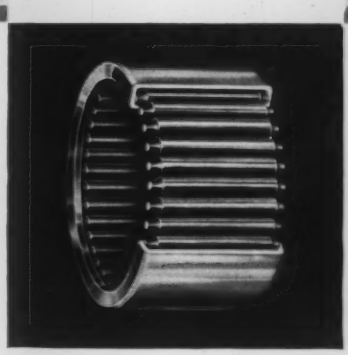
• • •

Resistance to corrosion by hot sodium is displayed by aluminum, making that metal a candidate for use as a nuclear barrier material. Researchers at Nuclear Development Corp., White Plains, N. Y., discovered that, after exposure of 16 hours to a 950-F jet of sodium, a piece of 0.06 in. aluminum was not corroded. Aluminum may therefore be a desirable material for use between the heavy-water moderator and steel tubes containing uranium fuel elements and sodium coolant in a nuclear reactor.



Positive roller retention during handling and assembly and effective lubricant sealing for many applications are two benefits of Torrington's experience-proved retaining lip construction.

This little lip makes a big difference!



The turned-in lip at each end of Torrington Needle Bearings positively retains the trunnion - end rollers and makes the bearing truly a complete unit, with no possibility of roller fall-out.

This unit construction simplifies installation and servicing. The closely controlled clearance and the large area between cup lips and shaft form an effective labyrinth seal. Also this retaining lip allows pregreasing the bearing with the proper lubricant for each application.

Long experience with the Torrington Needle Bearing in thousands of applications has proved the merit of this and other features in efficient performance and long service life. Make sure *your* product benefits from the best that experience has to offer—specify Torrington Needle Bearings. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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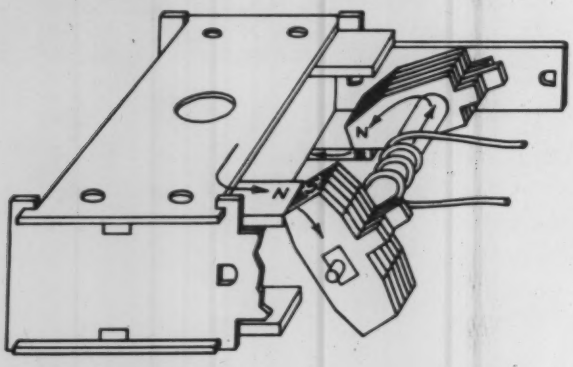
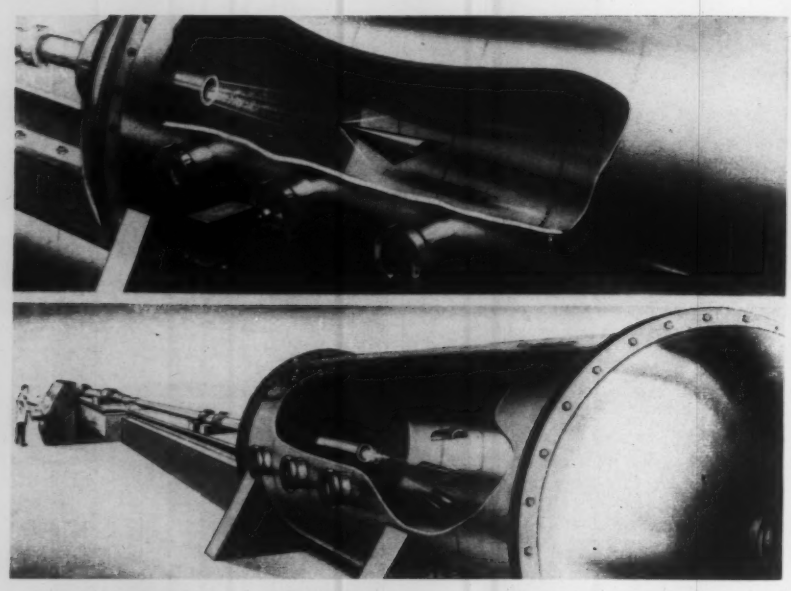
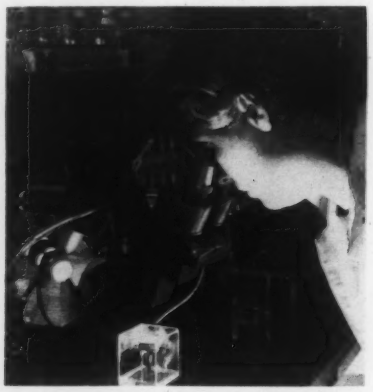


MAGNETIC DETENTING eliminates mechanical latching and holding current in the Magnetic Toggle Relay developed by American Electronics Co., Minneapolis, Minn. Key components are a permanent magnet and a wound rotating armature. When armature polarity is changed by reversing current flow, the relay toggles. One major advantage: MTR does not have an unenergized position. Power failure or temporary under-voltage has no effect on relay position. MTR also operates on a wide range of voltage, current, and frequency. Typical unit will work on 1 to 120 v, ac—60 to 400 cps—or dc. Activation time: 3 millisec. Rotary motion of armature permits use of commutator-type contacts for extreme shock or vibration applications.

SMALLER NETWORK TRANSFORMERS will result from a new spiral-core construction developed by General Electric's Distribution Transformer Dept. Called Evans Core, the new design will be incorporated in most GE 3-phase network units to reduce weight and increase efficiency. Partly assembled core for a 750 kva transformer is shown above. Two spirally wound inner cores link first and second and second and third phase coils. Third core is then laced around first two, linking first and third-phase coil.



HYPERSONIC WIND TUNNEL may be used two ways to test advanced missiles or space vehicles at speeds up to 13,500 rpm. One method will be to shoot high-pressure, high-velocity gas past a stationary model suspended in a test chamber. The second will be to drive projectiles through a 100-ft, 3-in. gun barrel and into test chambers at velocities of up to 20,000 fps. When in the gun barrel, the model will be surrounded by a sabot, which will separate upon reaching the two-stage test chamber. Test chambers may be evacuated to simulate upper atmosphere pressures for studies of space craft or missile re-entry. Scheduled for completion in 1960, the facility will be built by Convair (San Diego) Div. of General Dynamics Corp.



METAL WHISKERS solve riddle of failed electronic equipment. Here, technician at Boeing Airplane Co. of Seattle, Wash., examines growth of metal whiskers on a potentiometer. Visible under the stereomicroscope, the thin-walled, brittle tubes grow out of tin, zinc, and cadmium surfaces at rates up to 3/8 in. per year. Metal whiskers explain erratic behavior of electronic equipment, which may malfunction in the field but work perfectly in the laboratory. Invisible to the eye, metal whiskers short out equipment in the field, but are broken off during transportation to the laboratory, and so render the equipment operative again.

"Do It Yourself" Reactor To Be Assembled at Geneva

LEMONT, ILL.—A "do-it-yourself" nuclear reactor will be assembled at the Second International Conference on the Peaceful Uses of Atomic Energy. The Argonaut—Argonne National Laboratories' nuclear assembly for university training—will be assembled at Geneva for the September conference by a team of eight scientists.

Argonaut is a low-power, low-cost reactor of wide flexibility. It operates at an intermittent power of 10 kw, and its safety features and simplicity make it particularly well suited for training purposes. It measures approximately 20 ft long by 17 ft wide by 9 ft high.

Components were packed for shipment into nearly 50 large overseas crates. The articles range in size from a razor blade to a 5000-lb concrete shielding plug.

GRAVITY PIT IN SPACE, 4000 miles deep, is simulated by the curved sides of this table at the NACA's Ames Aeronautical Laboratory. Device helps visualization of satellite orbit and missile re-entry problems since table curvature is analogous to changes in the earth's gravitational field. Steel ball released from the demonstrator's hand follows a descending path like that of a satellite under the influence of air drag. Escape from earth is equivalent to the climb from the bottom of the pit to the flat surrounding plane.

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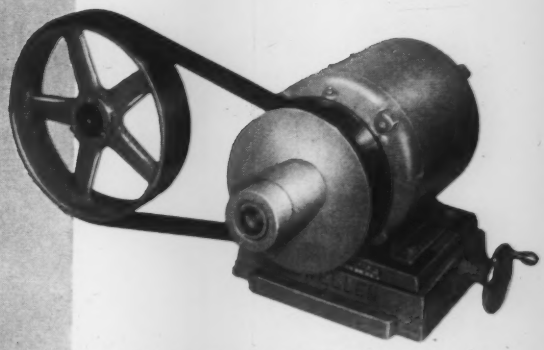

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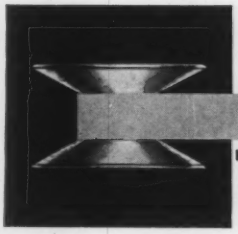

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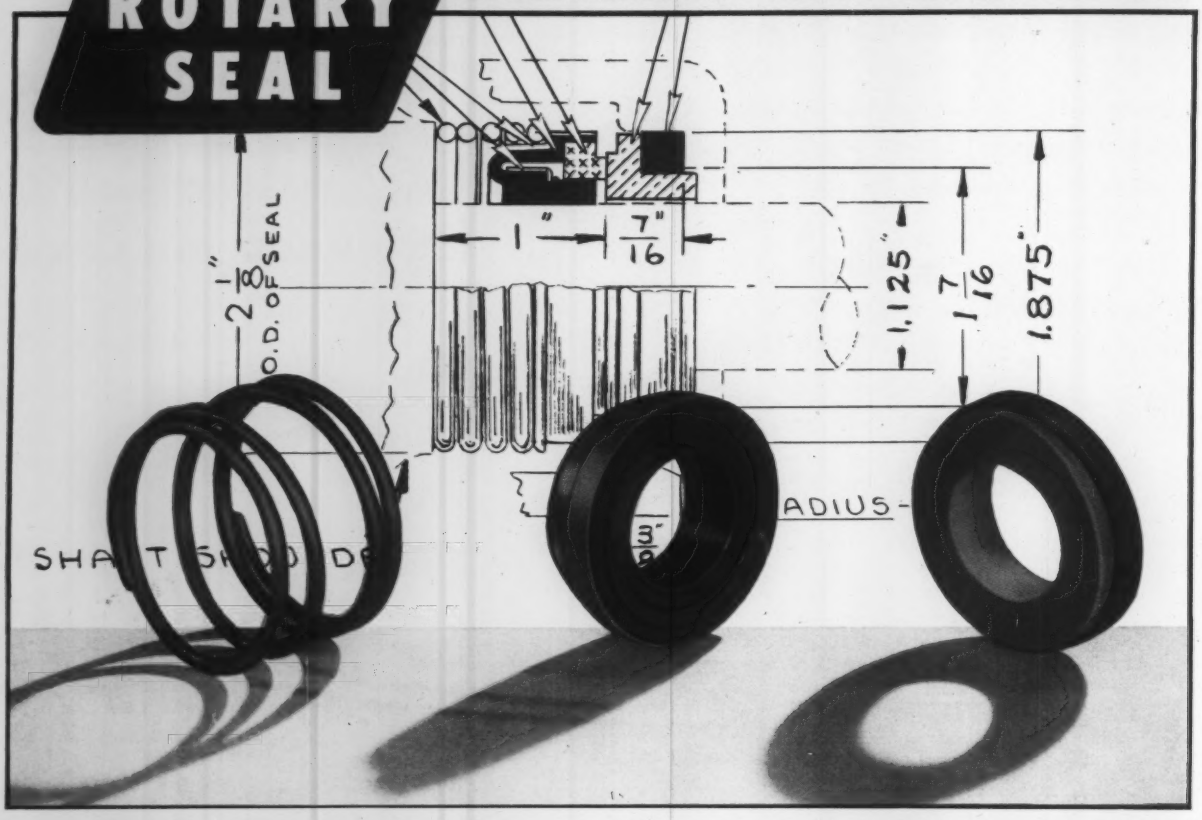
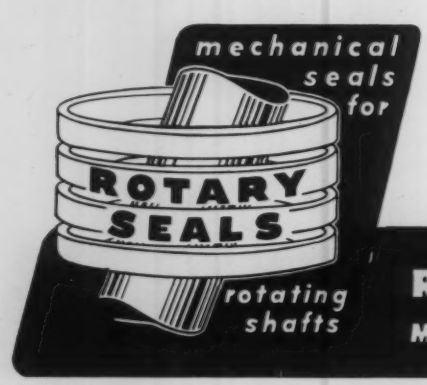


is developing new ways to assure top performance in DIFFICULT HEAVY-DUTY SEWAGE PUMP OPERATION

There are all sorts of pumps, for all sorts of purposes, and Rotary Seals of varying designs are in wide use along the whole range. But here's an application where the pump operates under some of the most extreme conditions you can imagine—in a heavy-duty sewage system. Often, the pump is completely drowned while working; and the kind of flowage it must handle offers difficulties of its own.

The Shaft Seal—at the operating heart of the pump—must obviously be built to "take it"—and keep on taking it, because constant maintenance or repairs are inconceivable under the circumstances. And, as so often is the case when the assignment is tough, it's a Rotary Seal (*custom-designed* to meet the unusual conditions) which is doing the job. That's our business: solving hard Shaft Sealing problems by applying the basic Rotary Seal principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

The best time to start solving your Shaft-Sealing problem is at the drawing-board stage. Call in our engineers for an early consultation—our experience with Seal applications of all kinds in many fields often indicates suggestions which can simplify design, lower costs and improve performance.



Shaft-Sealing with Certainty

ROTARY SEAL DIVISION
MUSKEGON PISTON RING CO., SPARTA, MICHIGAN

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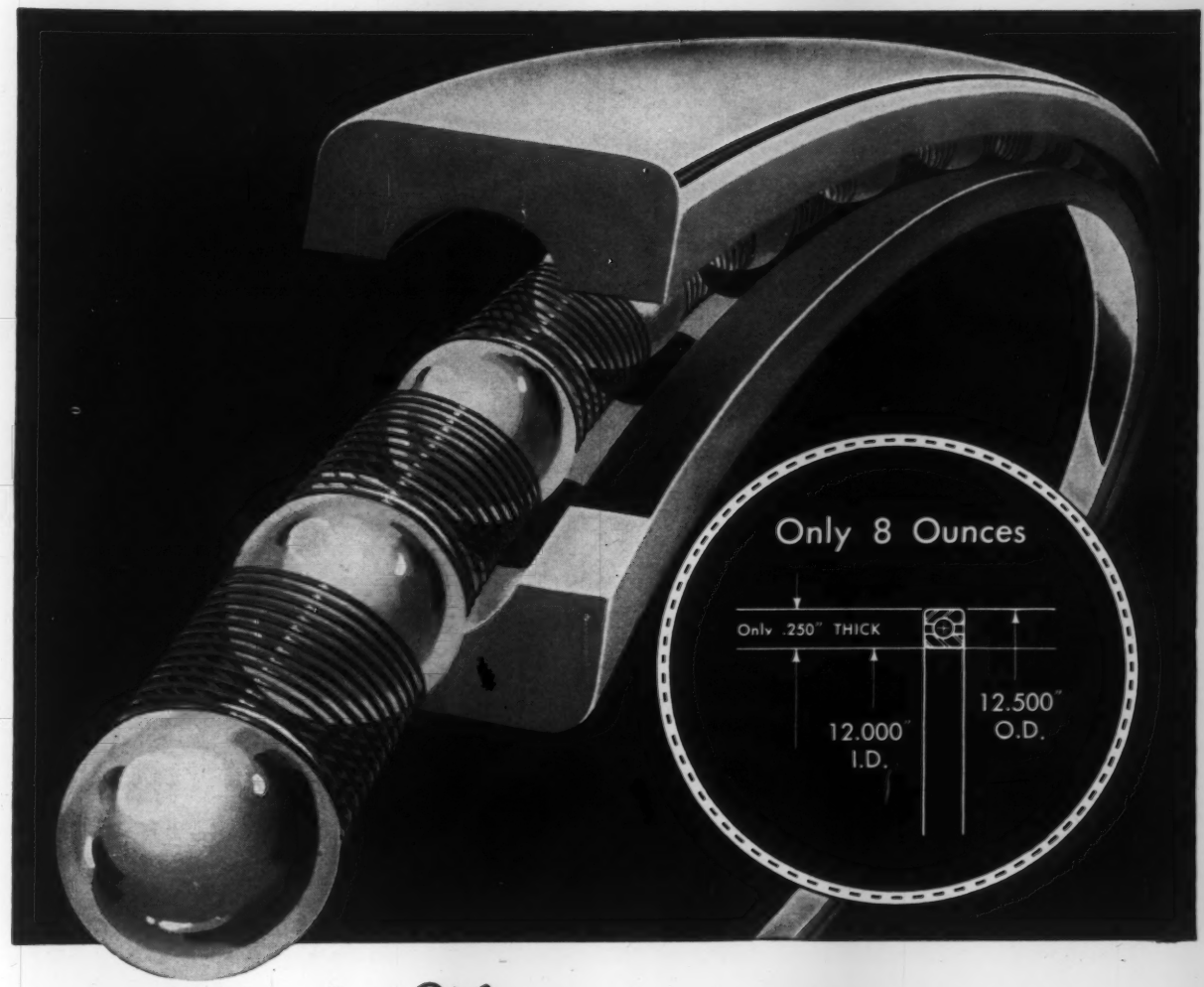

Reali-Slim... by Kaydon
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HERE'S a typical example of Kaydon's *Reali-Slim* unique radial ball bearing that's finding wide application in practically every industry. *Reali-Slim* are the world's finest thin-section bearings and proportionately are thinner than a wedding ring. The bearing illustrated here is 12.000" I.D., 12.500" O.D., .250" thick — weighs less than 8 ounces. Designed for minimum weight and space limitations, it has a static load capacity of 5,520 lbs. and 894 lbs. at 100 rpm.

If you're looking for *Reali-Slim*, lightweight, radial ball or roller bearings, look at Kaydon's *Reali-Slim* line. Besides hundreds of standard *Reali-Slim* designs, there's a wide variety of special races, seals and separators to meet special bearing problems. What's more Kaydon is able to produce these *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual. In addition, Kaydon bearing engineers are prepared to give you valuable help with technical bearing application problems.

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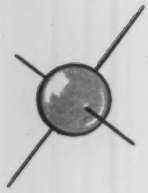
Circle 413 on Page 19

Halfway to Infinity

. . . a primer on earth satellites

By J. R. HURLEY and J. J. TABOREK

Mathematical Engineering Branch
Phillips Petroleum Co.
Bartlesville, Okla.

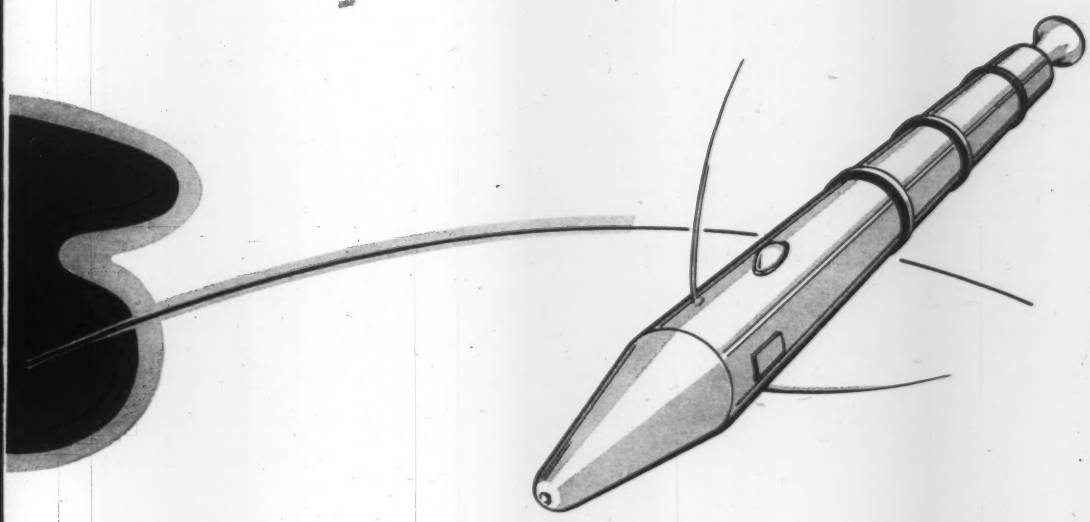


JOHANNES KEPLER was born 400 years too soon, but he could have described Explorer III's orbit with pretty fair accuracy. Explorer III, he would have noted, was a comfortable 1741 miles above the earth's surface at its high point (apogee) on the first day of its appearance. Across its orbital plane—at the opposite side of the earth—the satellite dipped to a perigee only 117 miles high.

Kepler would have needed assistance from Isaac Newton in explaining just why Explorer III's path was elliptical. Newton could have pointed out that Explorer III, like all satellites, was in a continual state of free fall. Balancing gravity against centrifugal force, it circled the earth in an eccentric, elliptical path, moving faster through its perigee, slowing down when climbing to its apogee. The elliptical orbit was, in a sense, a self-correcting path — one which permitted a perpetual and frictionless exchange of kinetic and potential energy as the satellite swept through the high and low points of its orbit.

In Kepler's time, and for three centuries following, the mechanics of satellites were an academic study. Astronomers and physicists could observe their motions, but never hope to put a satellite in an artificial orbit.

Today, earth satellites are engineered to do a job. How they move —and how they got up there—are questions of significance to an ever-widening audience. Here, in summary form, are the basic relationships for satellite launching and orbital motion.



Satellite Summary . . .

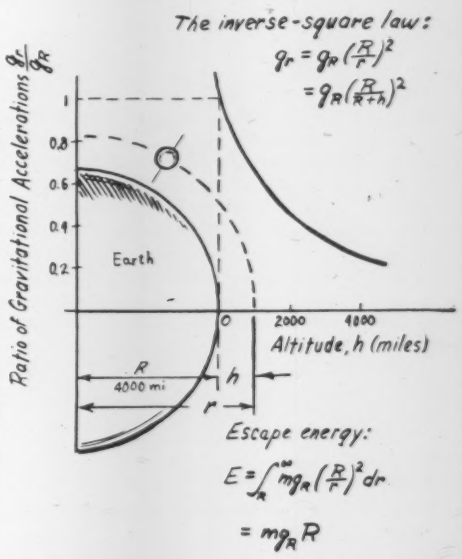
Satellite	Weight (lb)	Size	Period (min)	Apogee (mi)	Perigee (mi)	Launching Date	Life
Sputnik I	184	22.8 in. diam	96.2	560	145	10/4/57	2 mo
Sputnik II	1120	19 ft long 4 ft diam	103.7	1056	150	11/3/57	4½ mo
Explorer I	30.8	80 in. long 6 in. diam	114.5	1583	223	1/31/58	7 yr
Vanguard I	3.25	6.4 in. diam	134	2466	405	3/17/58	200 yr
Explorer III	31	80 in. long 6 in. diam	115.7	1741	117	3/26/58	3 mo
Sputnik III	2919	12 ft long 5 ft 8 in. diam	106	1168	150	5/15/58	6 mo

Escape From Earth

The gravitational attraction between two point masses diminishes as the square of the distance between them. This means that a man weighing 160 lb on earth weighs only 40 lb when he's 4000 miles up. At the distance of the moon (240,000 miles), earth's gravitational pull drops to 1/225 oz on each pound mass of the moon. Obviously, at an infinite distance, earth's gravitational effect is zero.

Work done in lifting a mass straight up against the pull of gravity equals the final potential energy of the mass. If gravitational force, *mg*, were constant—an approximation which is valid for distances small compared to the earth's radius—then infinite energy would be required to lift a body to an infinite height.

Fortunately for the future of space travel, the inverse-square gravitational relationship allows complete escape (to an infinite height) with the expenditure of a very large but still finite quantity of energy. Called escape energy, this expenditure amounts to about 21 million ft-lb per pound of mass. The mathematical expression for escape energy has an interesting interpretation: It gives the work that would be expended in a vertical climb through a distance equal to the radius of the earth—say 4000 miles—with constant sea-level value for the acceleration factor, g.



Velocity vs. Energy

The term "escape velocity," often used in connection with rocketry and celestial mechanics, is related to escape energy as follows: If escape energy is possessed by a body entirely in the form of kinetic energy, the body is said to have escape velocity. To project a body away from the earth's surface by means of a "cannon shot," the minimum muzzle velocity required is escape velocity. However, if a rocket is used for escape, the maximum rocket velocity required at burnout is less than "cannon-shot" escape velocity, that is, less than 6.95 miles per sec. This is because the rocket accelerates slowly, and by the time its maximum velocity is reached, some potential energy (height) has been gained. The result is to reduce the kinetic energy (velocity) required to bring total energy up to escape energy. The escape energy for a body already in orbit is the difference between total orbital energy and full escape energy.

Initial Kinetic energy = Escape energy, or

$$\frac{mv_e^2}{2} = mg_R R$$

∴ Escape velocity, v_e, is

$$v_e = \sqrt{2g_R R}$$

Tracks in Space

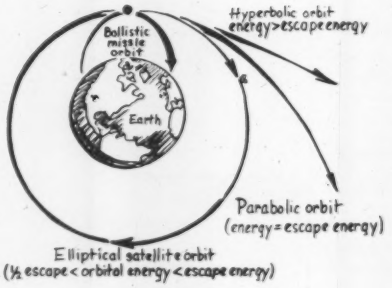
The trajectory of an object projected tangentially to the earth's surface takes one of four different forms, depending on how the body's total energy compares with the energy of escape:

1. Hyperbolic path. If the speed and therefore the energy of the object exceeds escape energy, it describes a hyperbolic curve with the earth at the focus. Receding from the earth, the object never returns.

2. Parabolic path. If the energy of the body exactly equals escape energy when it is released tangentially, it traces a parabolic path. Since the parabola is an open curve like the hyperbola, the body never returns.

3. Elliptical orbit. When energy of the projected body is less than escape energy (but more than one half escape energy), it describes an elliptical orbit. In this case the body is a true satellite, since it is held captive by the earth.

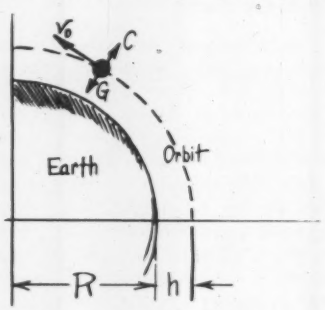
4. Ballistic trajectory. When the body's energy is less than one half escape energy, it traces a ballistic trajectory, which is also elliptic. This ellipse, however, intersects the earth.



The Balanced Forces

A missile ejected vertically into space at less than escape velocity is attracted back to earth by gravitational forces. To keep a satellite in orbit, it must be given a start in a circular or elliptical path around the earth. The required orbital velocity v_o and height h can be deduced from equilibrium between the attractive force of gravity and the centrifugal force created by the circular motion. At any instant these two forces must be equal and opposite.

From the law of gravitation, it becomes apparent that the higher an earth satellite, the smaller the centrifugal force it must develop to counterbalance the earth's gravitational pull. So, orbital speed for distant satellites should be less than for close satellites. This is indeed the case, for man-made satellites speed around the earth at about 17,000 mph at an altitude of a few hundred miles, while the moon, nearly a quarter million miles away, plods along at a mere 2300 mph.



Gravitational force = Centrifugal force, or

$$mg_R\left(\frac{R}{R+h}\right)^2 = \frac{mv_o^2}{(R+h)}$$

∴ Orbital velocity, v_o, is

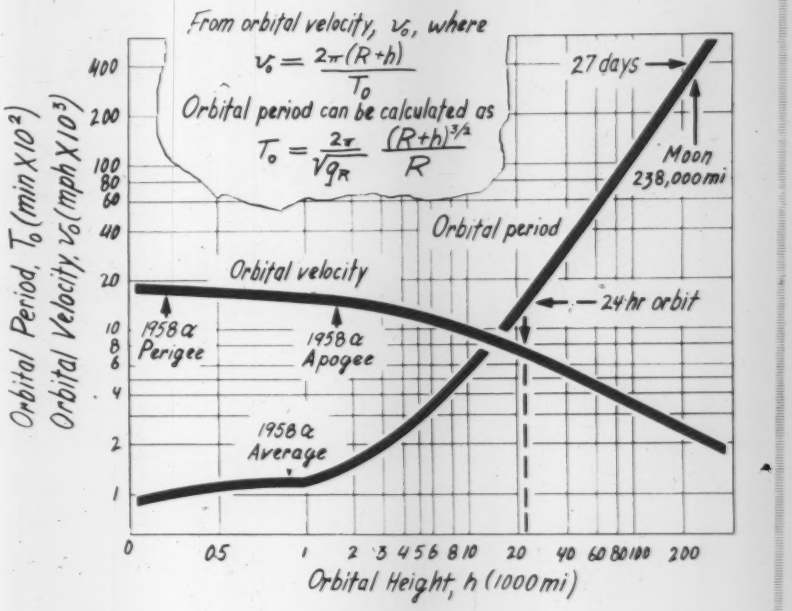
$$v_o = R\sqrt{\frac{g_R}{R+h}}$$

Note: For close-in orbits, $h \to 0$, and

$$v_o = \sqrt{g_R R}$$

"Stationary" Moon

Two important conclusions can be drawn from the mathematical expressions for satellite orbital velocity and period: 1. Orbital velocity is independent of the mass of the body. 2. Orbital height uniquely determines velocity and period. A special orbital case is that of a satellite with a 24-hr period. If such a satellite could be placed in a circular orbit moving from west to east, it would appear to hang motionless in the sky. Deviations in orbital direction and ellipticity of the orbit would cause only small oscillations in the apparent position of the satellite. Substitution of a 24-hr (86,400 sec) period into the expression for period vs. height gives the orbital height of a 24-hr satellite as 5.7 earth radii or 22,600 miles.



Launching a Satellite

The concept of effective launching velocity for a satellite is based (like escape velocity) on the idealized assumption that all the energy required is supplied in a short initial impulse. Speed, and therefore kinetic energy, increases during this impulse to such a value that it accounts for the total energy requirement of the final orbital state.

The energy which must be expended to eject a body of mass m to the height h is equal to the potential energy this body will ultimately possess in relation to earth. If it is further desired that the body have a certain final velocity at height h, the total energy of such body with respect to earth will be the sum of its potential and kinetic energies. For close-in orbits, altitude h becomes almost negligible with respect to R, and the potential-energy requirement becomes zero. The total energy of most man-made satellites is therefore equal to their kinetic energy alone.

It is interesting to note that the kinetic energy of a close-orbit satellite ($h = o$) is equal to one half of its full escape energy. In other words, twice the energy is required to place an object on the moon's surface as to put it into a close-in orbit. On the contrary, the orbital velocity (and therefore orbital kinetic energy) for a satellite at a great distance approaches zero as h approaches infinity. Total energy of a distant satellite therefore equals its potential energy only.

Total energy = Potential + Kinetic, or

$$E_o = mg_R R\left(\frac{h}{R+h}\right) + \frac{mR^2 g_R}{2(R+h)}$$

or,

$$E_o = mg_R R\left[1 - \frac{R}{2(R+h)}\right]$$

For close-in orbits, $h \to 0$, and

$$E_o = \frac{mg_R R}{2}$$

Effective launching velocity, v_f, is given by

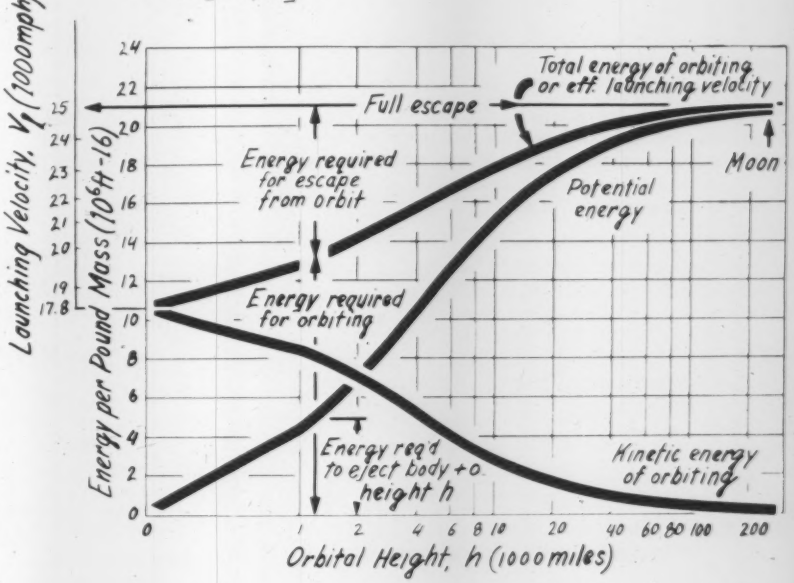
$$\frac{mv_f^2}{2} = mg_R R\left[1 - \frac{R}{2(R+h)}\right]$$

or,

$$v_f = \sqrt{\frac{g_R R(2h+R)}{(R+h)}}$$

For close-in orbits, $h \to 0$, and

$$v_f = \sqrt{g_R R}$$


Launching Velocity, v_f (1000 mph)
Energy per Pound Mass ($10^6 H - 16$)
Total energy of orbiting or eff. launching velocity
Full escape
Energy required for escape from orbit
Potential energy
Moon
Energy required for orbiting
Energy req'd to eject body + o height h
Kinetic energy of orbiting
Orbital Height, h (1000 miles)

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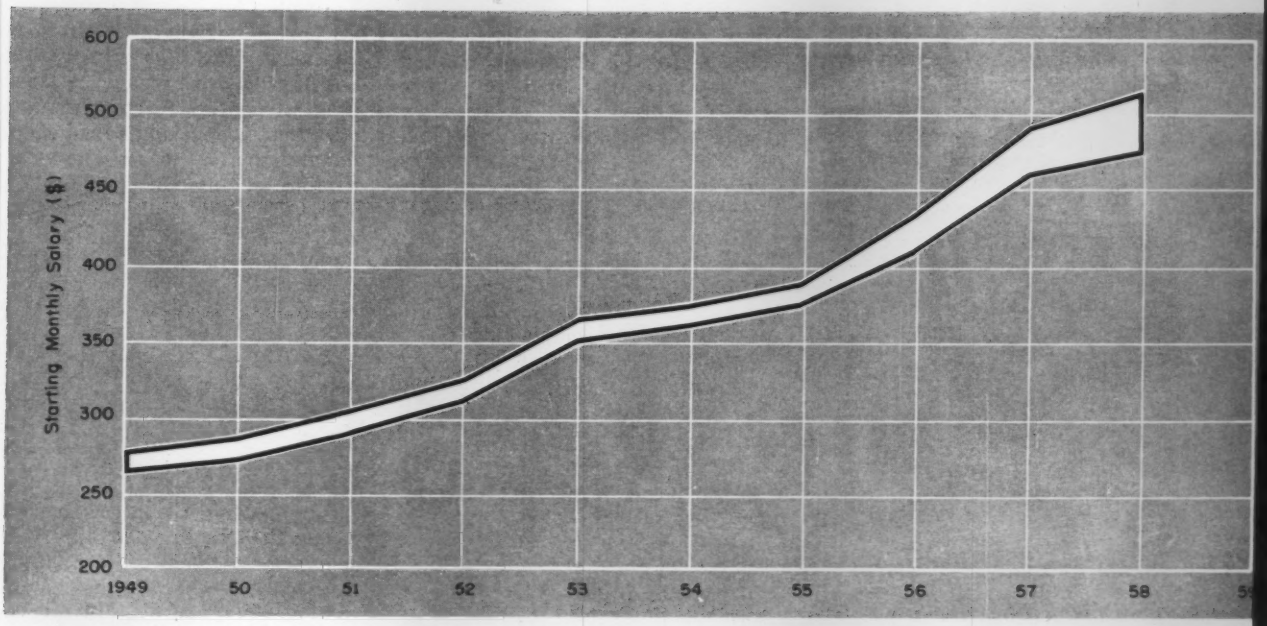
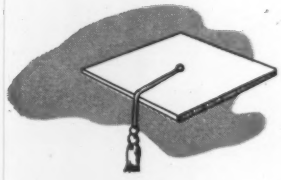




CHOOSING THE JOB

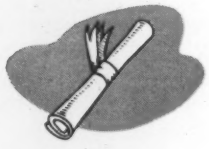
These factors influenced engineering graduates

1. Type of work offered
2. Location of company
3. Training program offered
4. Salary offered
5. Reputation of company
6. Opportunity for advancement
7. Size of company
8. Company interviewing policies
9. Other reasons

CHOOSING THE ENGINEER

These factors influenced company interviewers

1. Personality
2. High marks
3. Activities
4. Specialized courses
5. Part-time work
6. General courses



Trend Still Up In

ENGINEERS' STARTING SALARIES

FOR THE NINTH SUCCESSIVE YEAR, starting salaries accepted by new engineering graduates have increased. The gain in '58: A modest 5 per cent. This compares to a yearly boost of 10 per cent in both 1956 and 1957, according to MACHINE DESIGN's annual check of the pay picture.

Reports for the 1958 survey were received from 11 representative engineering colleges. Averages of starting salaries for all engineer graduates in all 11 schools occurred in the range of $475 to $515. These were $10 to $25 higher than last year.

Taking note of the continual upswing, Civil Service recently won a 10 per cent raise for all engineers and scientists employed by the government. The increase covered all civil service grades. Starting salary for a B.S. degree with no experience is now $4980. Most governmental agencies engaged in scientific or engineering projects take further steps to compete with industry. One agency automatically raises its engineers one grade — to $5985 — after six month's service.

Again in 1958, electrical engineers accepted top salaries. Averages, per college, ranged from $480 to $535. All other degrees followed close behind, in line with the overall average, and with little signifi-

cant variation. One exception might be noted for Lehigh University's metallurgical engineers. Demand outstripped supply, and the group of 21 candidates collectively suffered a total of 295 interviews. They ended up with a higher average salary—by $12 — than all other Lehigh engineers.

Over-all demand, however, placed a priority on electricals as salary indicates. Mechanical engineers were second in line by a factor of 33 per cent.

Although few new engineers are without engineering jobs, demand seems to be leveling off. The number of recruiters on college campuses this spring was about the same as last year, but colleges reporting to MACHINE DESIGN agreed unanimously that recruiters were more selective than in past years. Columbia University's placement director, Samuel H. Beach, observed that many companies expected to fill quotas with top men only. Since the demand in this category seldom slackens, these companies "had to lower their too-high sights. A number of companies, not wishing to do this, did not fill their quotas," said Mr. Beach.

Donald P. LaBoskey, placement director at University of California, Los Angeles, reported demand down about 5 per cent, and noted that recruiters were taking advantage of the situation by focusing more attention on personal qualifications over and above academic standing.

Personality was evidently the most important factor to the majority of recruiters in sizing up a potential engineering employee. In a comprehensive survey by Northwestern University's Frank S. Endicott, 223 leading companies were asked to rank qualifications they sought in new engineers. Personality ranked first; academic standing was second.

The major preference of new diploma holders, in selecting a company, was the type of work offered. Four or five other factors preceded salary, according to their replies. This is a good sign in more ways than one. If salary was of first significance, the annual rise might be quite startling.

Average Starting Salaries Reported by 11 Colleges

Curriculum	1957	1958
Aero. Eng.	$460-490	$480-505
Mech. Eng.	460-490	465-510
Elec. Eng.	475-490	480-535
Ind. Eng.	445-460	465-510
Eng. Physicist	465-480	470-515
Civil Eng.	460-475	460-510
Chem. Eng.	455-480	475-500
Met. Eng.	460-470	465-500
All Eng.	460-490	475-515

Massachusetts Institute of Technology; Columbia University; University of Pennsylvania; Lehigh University; Case Institute of Technology; Purdue University; University of Michigan; Northwestern University; California Institute of Technology; University of California, Los Angeles; Georgia Institute of Technology.

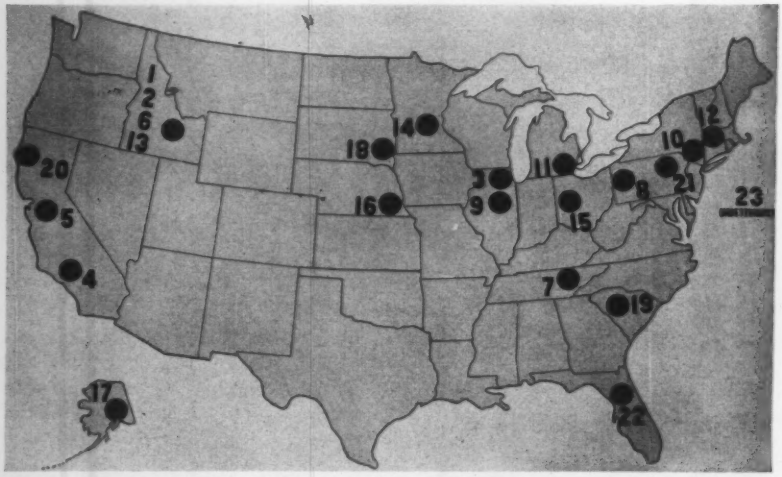
Plan 23 Atomic Reactors in U. S. by 1964

But Competitive Power Seen Long Way Off

WASHINGTON—The year 1964 will see 23 civilian nuclear reactors located throughout the United States, including Alaska, according to former chairman of the Atomic Energy Commission, Lewis L. Strauss. Recently summarizing progress of the AEC since early 1952, he found, "The most conspicuous effort to extend the peaceful uses of atomic energy is the development of civilian power reactors."

"Serious problems remain to be solved," said the former AEC chairman, "before we have a self-sustaining nuclear power industry. It is not yet clear that a nuclear power plant can be built in the United States to generate electricity as economically as a conventional plant. In Europe, nuclear power can be competitive almost immediately. We hope, by building reactors for our friends in Europe who need them, to learn how to build and operate reactors that will be economical in the United States."

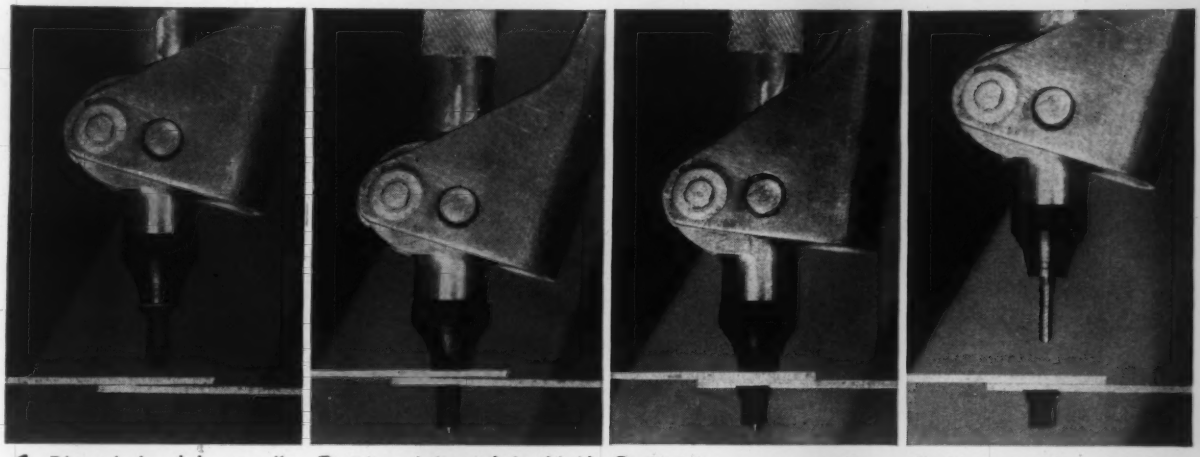
According to Strauss, four plants representing private capital investment of $250 million, and more than half of the total kilowatts shown on the bar graph, are now under construction without any taxpayers' money committed to the bricks and mortar or hardware. He pointed out that for the eight jointly sponsored projects not yet under construction, AEC funds of $150 million for hardware and other assistance are more than matched by industry commitments of $200 million. He



Map shows 23 power reactor projects scheduled to be operating in 1964. U. S. progress in civilian reactor construction is evidenced also by projects involving construction of reactors to be installed in other countries. Pending agreement with six-nation Euratom group contemplates U. S. assistance in construction and operation by 1963 of reactors to produce 1 million kw of electricity. Military power reactors are not included.

B.F.Goodrich

Rivnuts® fasten thin metal... provide 6 threads in 6 seconds

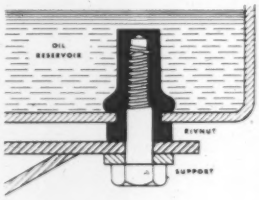


1 Rivnut is threaded onto pull-up stud of heading tool.

2 Rivnut is inserted—head held firmly against work.

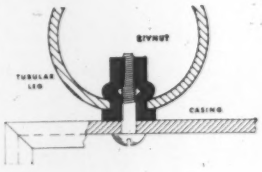
3 Tool lever operates pull-up stud, forms bulge in Rivnut.

4 After upset, Rivnut threads are ready for screw attachments.



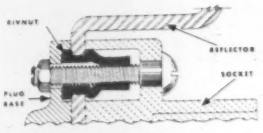
REPLACES BRAZED NUT PLATE

Rivnuts with closed ends are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated, and spacer head assures proper positioning of tank on support bracket.



ELIMINATES NUTS AND BOLTS

One worker installs a Rivnut in the tubular leg of a portable barbecue in seconds—provides a firm, accurate nut plate for screw attachment. There are no boltheads to detract from the unit's clean lines. Time is saved, too, in faster knockdown for shipping.



DOES 2 FASTENING JOBS

Rivnuts provide 6-thread nut plate for attachment from either end—or both. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket. Plug base is attached on other side. Result: fewer operations, lower assembly cost.

B. F. Goodrich Rivnuts—the easy way to cut assembly time . . . costs

Rivnuts, the only one-piece blind fasteners with threads, can be installed by one person from one side of the work—in seconds. Easy installation saves up to 50% of assembly time, reduces production costs. Rivnuts can also improve the appearance of your products and make them easier to use and service.

Rivnuts are made in a variety of sizes and head styles to solve almost any fastening problem. They make tight, dependable seals that resist vibration, stay put so you can assemble and disassemble the product as often as you like without stripping the threads. Welding, tapping and thread cleaning are eliminated. And you can install Rivnuts after enameling without fear of chipping.

B.F.Goodrich Rivnuts have speeded up thousands of fastening jobs. They can do the same for you.

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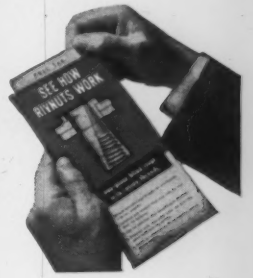

B.F.Goodrich aviation products

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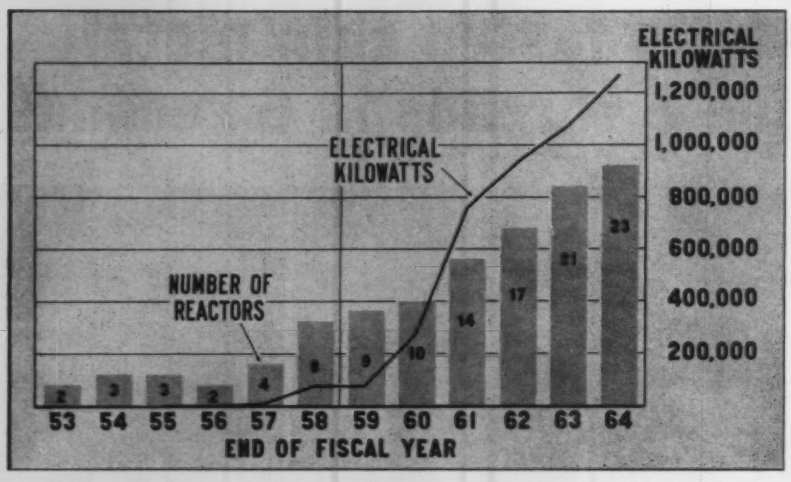


Bar chart shows growth in civilian power projects since 1953. Bars represent the number of reactors. In 1953, there were two small reactor experiments. The electric power they produced barely met their own plant requirements. Eight civilian power reactors and reactor experiments operated in fiscal year 1958. Chief among them is the 60,000-kw Shippingport Atomic Power Station, first operated last December. Many more power reactors are under construction and others are scheduled. Bars show the number of these which will be in full operation in each year to 1964, when the number is 23. Curve shows total capacity of about 1,300,000 kw.

also discussed the AEC's own experimental program which includes reactor experiments to explore and test 10 design concepts. These, he suggested, may be thought of as 10 different attacks upon the problem of achieving economical nuclear power. The AEC experimental program also includes co-ordinated attacks on problems common to many reactor designs, including fuel development, chemical processing, shielding, reactor safety, and waste disposal.

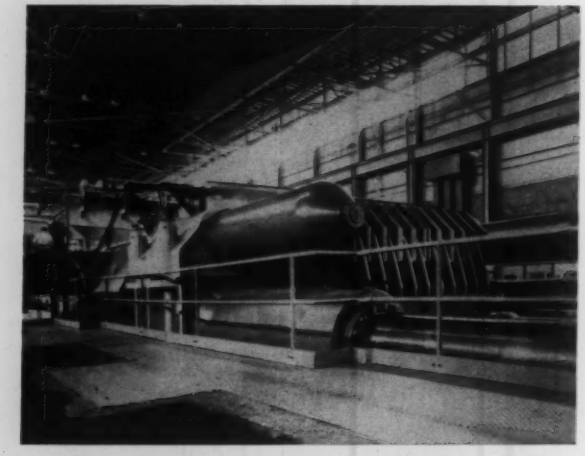
Rigid Urethane-Freon Foam Forms Exceptional Insulation

Cool New Designs Seen in Refrigeration

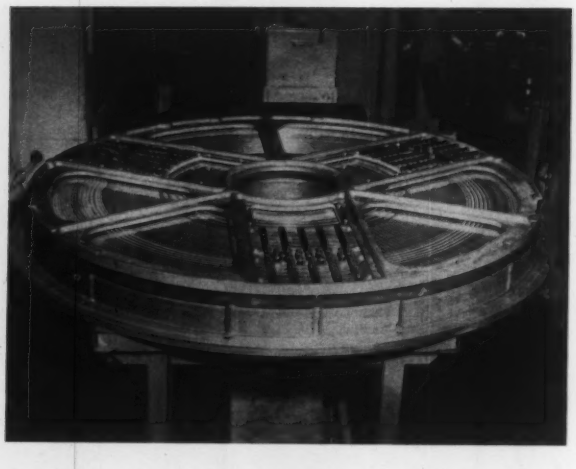
DAYTON, OHIO—Space saving made possible with a new insulating material, developed by Frigidaire Div., General Motors Corp., can increase the usable interior space of a conventional refrigerator by 50 per cent. A 1¼-in. thickness of the new material is said to equal 3 in. of conventional insulation.

R. E. Gould, Frigidaire's chief engineer, predicts that the new insulation will not only change the appearance and design of conventional refrigerators and freezers, but will also change the size, shape, and construction of many other home and industry refrigeration devices.

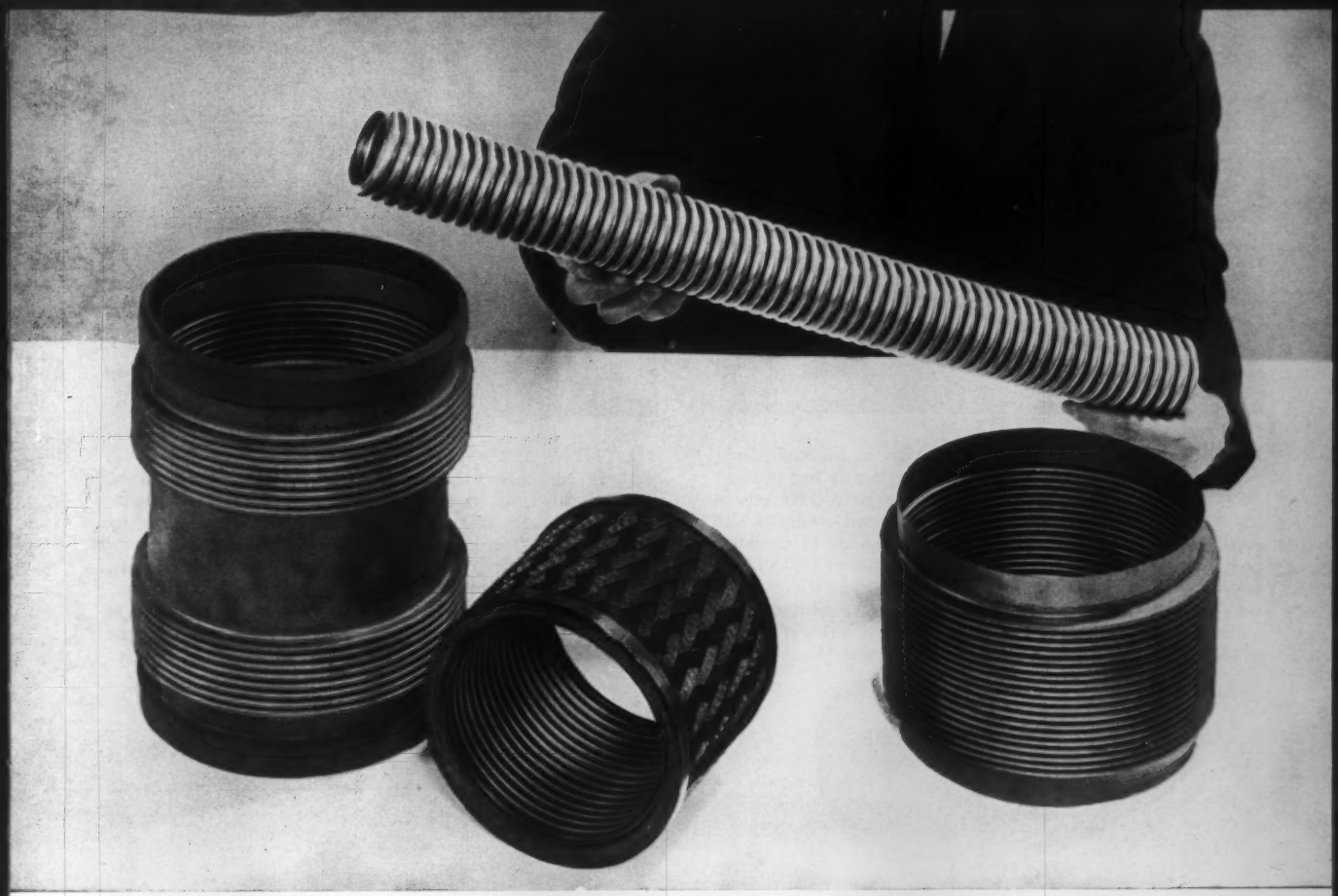
In use, a small quantity of the new urethane-Freon combination is poured between the walls of a refrigerator. Within minutes, the material foams and rises like dough to fill the entire space. It soon becomes rigid, adheres to all surfaces, and becomes a strong, integral part of the structure. Thousands of tiny cells formed in the rigid urethane contain Freon, which has extremely low conductivity.



FAST STRETCH for thick aluminum plate is provided by the 8000-ton pull of ALCOA's new plate stretcher. Developed by Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp., the big machine handles stock ranging to 6 in. thick and 152 in. wide; stretches it at the rate of 22 in. per min. Desired degree of stretch-straightening is obtained by setting pressure to a predetermined stress, or by stretching the plate to a predetermined length. One man controls the operation from a console. Machine itself is 160 ft long and weighs 2750 tons.



RADAR SLIP RING and brush assembly, 48 in. in diameter, is said to be one of the largest precision slip rings ever manufactured. The brush rigging comprises nine brush yokes containing three groups of three blocks each, or 53 separate circuits. Slip-ring disk, containing 53 concentric precious-metal rings, is a single-piece plastic casting of specially formulated epoxy resin, dielectric bonded to an aluminum alloy backing plate. Electro-Tec Corp. designed the big unit for Air Force's AN/FPS-26 Intercept Radar System.



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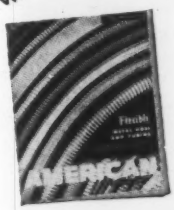

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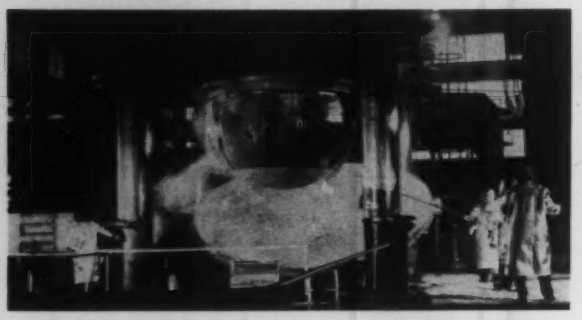
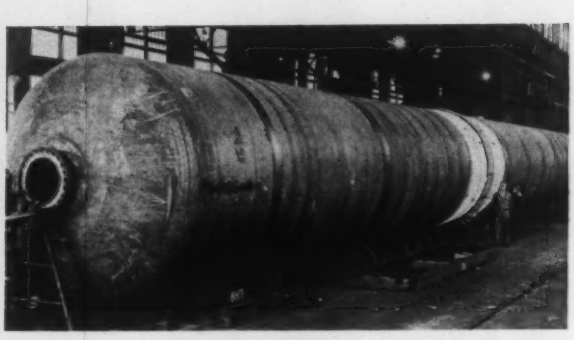
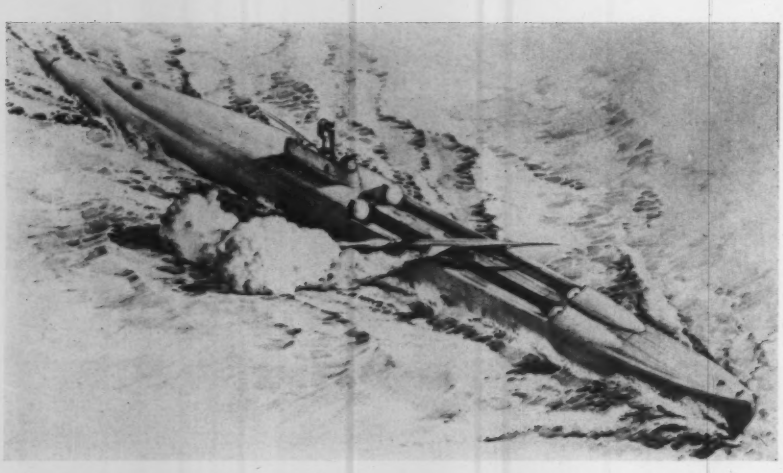


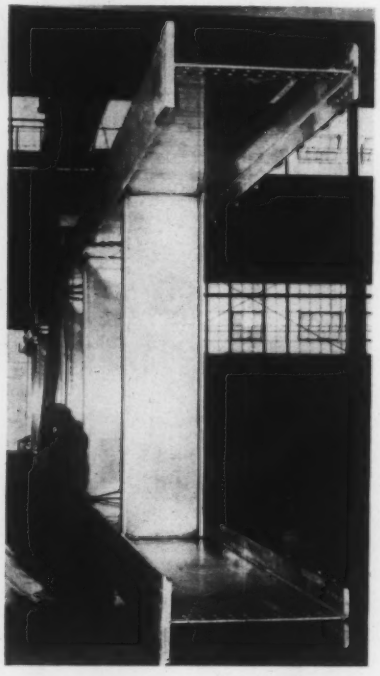
DIE-FORMING ON A BIG SCALE is used by Babcock & Wilcox Co. to make pressure heads for nuclear powerplants. Circular workpiece shown above is 15 ft in diameter, 8 in. thick, and weighs 29 tons. It's formed, in a single stroke, into an 11-ft diameter hemisphere 5½ ft deep. Steel plate of 70,000 psi tensile strength SA 212, Grade B, carbon-silicon steel was heated to 2000 F prior to forming. Finished pressure vessel will be used in Consolidated Edison's 275,000-kw generating station at Indian Point, N. Y.



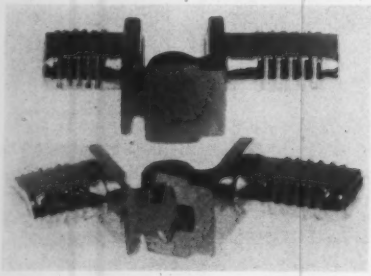
HEATING PAD FOR STRESS RELIEF, containing 400 ft of chrome-nickel resistance wire, was coiled around the final welded joint of this 114-ft long storage tank. Job was accomplished without having to move the big tank to an induction furnace; relief obtained is reportedly superior to induction heating, and 1/10 as costly. Heating wire, developed by Acros Corp., Philadelphia, is insulated with ceramic beads. In this application, it provided 1100 F heat, drew 190 amp at 190 v dc. Weld was heated for 4 hr, then cooled slowly.



GUIDED-MISSILE SUBMARINE shown in this artist's conception is one of several nuclear-powered models included in Navy's 1959 construction program. The sub surfaces to launch its missile, which indicates that it is not a Polaris carrier. Prototype propulsion system—turbines, reduction gear, and turbine generators — is being designed by De Laval Steam Turbine Corp. The company will also furnish propulsion electric motor, propulsion clutch, main condensers, and main thrust and shaft bearings.



RIGHT FROM THE DIE, and all in one piece, these Intercast hinges eliminate the usual process of assembling two hinge halves with a hinge pin. Hole drilling and tapping are also eliminated. Studs with annular teeth are cast to the movable hinge leaves; hinges are fastened to a desired part in a single press stroke. Gries Reproducer Corp., New York, developed the high-volume process to make hinges for eyeglass frames Fit between mating parts of the zinc-alloy hinge is unusually good, as photo above shows. Separation line is barely visible. The process limits hinge size to 1.5 in.



FIRST ALUMINUM - GIRDER BRIDGE, soon to be constructed near Des Moines, Iowa, will be supported by four continuous longitudinal girders spaced 9½ ft apart. Bridge will be 222 ft long, 36 ft wide, with a 30-ft roadway. Inert gas shielded arc welding process was used in fabrication of the high-strength alloy plate that ranges in thickness from ½ to 1¾ in. Girder system was fabricated by Pullman-Standard Car Mfg. Co. Alcoa, Kaiser Aluminum, and Reynolds Metals supplied aluminum.

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This broad experience can prove of equal value to you. Send for more information about this new switch. Request Data Sheet No. 148.

—•—

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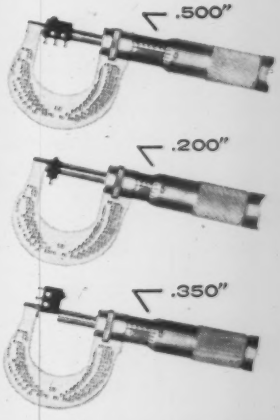

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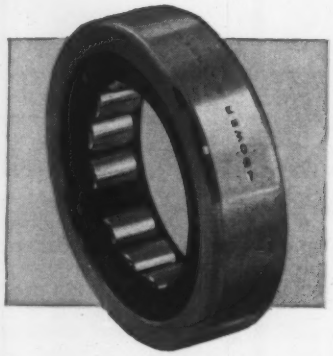
Circle 417 on Page 19

"ROUGHNECKS" IN ACTION . . .

And this phrase describes the *equipment*, as well as the men who handle such back-breaking work! Bearings, for instance, have to operate efficiently under tremendous loads around the clock . . . day in, day out. Bower cylindrical roller bearings are engineered for jobs like this—incorporating such advanced design features as integral thrust shoulders and raceway, and improved internal construction. Painstaking quality control makes them last longer, require little or no maintenance. If you use bearings, either in original equipment or for replacement purposes, specify Bower!



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ROLLER BEARINGS

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Volkswagen Uber Alles

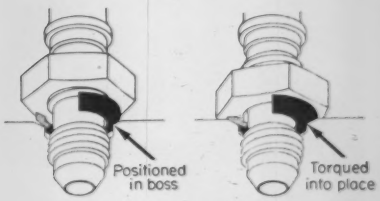
Germany's Best-Known Export Wins U. S. Sperry Award

NEW YORK—It's been called the "Model T of the Jet Age" . . . a persistent rumor says it's "Made in der Black Forest by der elfs" . . . some owners claim that it's not only a mode of transportation, but a state of mind.

Whatever it may be, Volkswagen last week showed its heels (unfinned) to Detroit "iron" in chugging off with one of America's leading engineering honors: The 1958 Elmer A. Sperry Award. This is the first time that the Sperry award —presented in recognition of distinguished contribution to the art of land, sea, or air transportation—has been given to a foreign engineer or engineering team.

Named as recipients were Dr. Heinz Nordoff, director general of the Volkswagenwerk, the late Dr. Ferdinand Porsche, designer of the car, and their co-workers. The award citation, in part, reads: ". . . an automobile of small size for multiple uses, with unique attributes of universality; of low initial and operating costs; of simplicity of design having ease of maintenance; comfort with adequate performance . . ."

The Sperry award is administered by representatives of four major engineering societies: American Society of Mechanical Engineers, American Institute of Electrical Engineers, Society of Naval Architects and Marine Engineers, and Society of Automotive Engineers. Previous recipients include William F. Gibbs, designer of the *S. S. United States*, Donald W. Douglas, creator of the "DC" aircraft series, and the developers of the General Motors diesel-electric locomotive.



SIMPLE, ALL-METAL SEAL, effective from −360 to 1200 F, and from 0 to 10,000+ psi, is a recent by-product of missile development at Autonetics Div., North American Aviation. Made of aluminum, stainless steel, or Inconel-X, the seal deforms under torque to become an integral part of the hydraulic fittings. Seal efficiency is claimed unaffected by frequent disassembly of fittings. Navan Products Inc., Santa Monica, Calif., is licensed to distribute the seal commercially.

Atom Angles

Safe beta-ray handling in industry is outlined in the new American Standard Z54.2-1958. Entitled "Safe Design and Use of Industrial Beta Rays," the standard gives information on how to handle beta-ray sources safely, how to set up a safety program for continuous protection against beta rays, and what to do if an accident should occur. Beta rays are widely used for measuring thickness of such materials as paper, plastic sheets, rubber, cellophane, and coated materials. The National Bureau of Standards, which sponsored the standard, has also published it as Handbook H66.

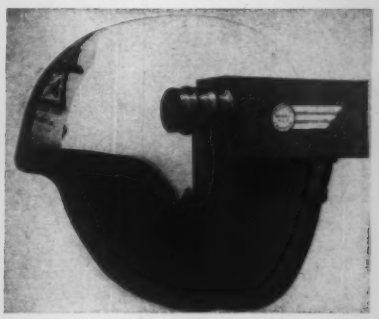
• • •

Nonnuclear uses of uranium will be resumed with recent lifting of AEC prohibitions. Depleted uranium (material from which a part of the fissionable U-235 has been removed—contains less than the 0.7 per cent by weight of uranium 235 present in natural uranium) will be made available for sale from Commission stocks on an unclassified basis. Removal of restrictions on uranium uses will allow industry to resume industrial applications prohibited since World War II, such as uses in ceramics and glass products, primarily as a coloring agent, and in photographic films, negatives, and prints. Either normal uranium, purchased from private industry, or depleted uranium may be used.

Largest known rate-of-power increase to have been experienced safely by a reactor, amounting to tripling the power every 0.002 sec, occurred recently in the AEC's nuclear research reactor, KEWB. Power output jumped from 0 to 530,000 thermal kw in less than a second, and the reactor shut itself off without sustaining any damage. The surge occurred in a special test to study the behavior of an aqueous homogeneous reactor if operating control were lost. Far more fissionable uranium than required for normal operation was made available for a chain reaction by sudden removal of the control rod. The special test demonstrated the inherent ability of this reactor to shut itself down without the use of auxiliary control rods or devices under abnormal operating conditions.

• • •

Geneva exhibit plans, announced recently by the AEC, encompass the whole range of peaceful uses of atomic energy and will include actual operating devices being used in research efforts to harness the forces of thermonuclear energy. The U.S. presentation will include two operating research reactors, over 700 technical papers dealing with peaceful aspects of atomic energy, and fusion-research experimental devices in actual operation. The conference will take place Sept. 1 to 13.



HELMET MOVIE CAMERA answers pilot's data-recording problems where small space and light weight are essential. Designed by the Vought Co. of Beverly Hills, Calif., especially for use on pilot's protective helmets, it operates at 24 frames per sec at 24 v dc; carries 30 ft of 16-mm film.

Latest commodity in the electronics field is a new and very scarce type of management official, the National Federation of Financial Analyst Societies was told at its recent annual convention. Describing the scarce commodity, R. T. Silberman of Cohu Electronics Inc., said, "A new line of management blood is now being evolved in scientific industry—the composite scientist and administrator with profit consciousness. This man is the really scarce commodity in our society today. He is basic to producing real results."

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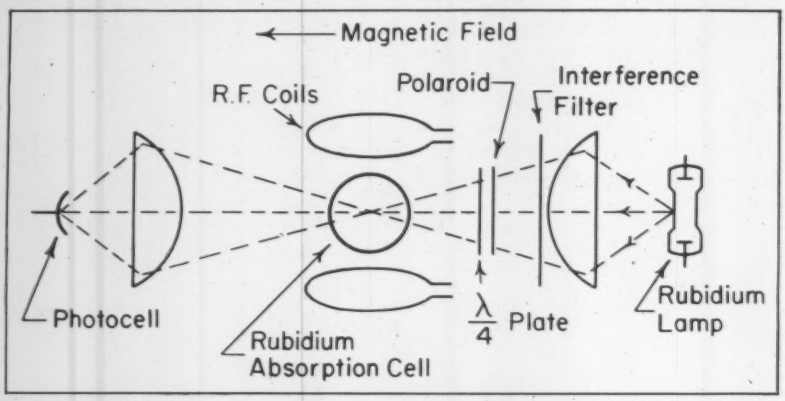
Can Measure Magnetism In Earth and Outer Space

Precise Method Employs Light Absorption by Atoms

WASHINGTON—A method of measuring the magnetic forces that originate inside the earth and in outer space has been developed by two Commerce Dept. scientists. The method, developed by T. L. Skillman of the Coast and Geodetic Survey and Dr. P. L. Bender of the National Bureau of Standards, is expected to provide scientists with magnetometers far more precise and compact than those now available.

A beam of light is sent through a tube containing a small quantity of vaporized rubidium (one of the alkali metals). Light absorption by the rubidium indicates strength of the magnetic forces. The explanation is that absorption of the light depends on the spinning of the elec-



In rubidium vapor magnetometer, light from Rb lamp is circularly polarized by a polaroid sheet and a ¼-wave plate and then passed through an absorption cell containing Rb vapor and an inert buffer gas. The magnetometer is oriented so that the light beam is roughly parallel to the magnetic field. The amount of transmitted light is monitored by a photocell. Interference filter used on the lamp passes the strong Rb optical line at 7943 A but not the one at 7800 A. Because the Rb atoms tend to line up with their magnetic moments along the direction of the magnetic field, the atoms then absorb less light than normally, and the amount of transmitted light will be larger than if the atoms were randomly oriented. A radio-frequency field is now applied at right angles to the magnetic field. This changes orientation of the atoms and the amount of light absorbed. If the applied frequency is swept through the resonance value, the absorption lines will be observed as dips in the output of the photocell. The resonant frequency indicates intensity of the magnetic field. Photo (below) shows Mr. Thomas L. Skillman with development model of the instrument.

HALF the world is half asleep! Men who could be making *twice* their present salaries are coasting along, hoping for promotions but doing nothing to bring themselves forcefully to the attention of management.

They're *wasting* the most fruitful years of their business lives . . . throwing away thousands of dollars they may never be able to make up. And, oddly enough, they don't realize—even remotely—the tragic consequences of their failure to forge ahead while time is still on their side.

Engineers and other technically-trained men are particularly prone to "drift with the tide" because their starting salaries are reasonably high and promotions come at regular intervals early in their careers. It isn't until later—too much later in many cases—that they discover there is a definite ceiling on their incomes as technicians.

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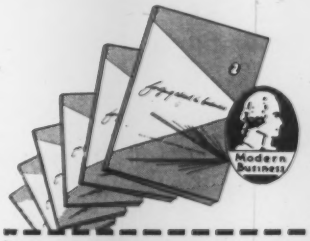
If you want to discover how to succeed while you are still young—if you want to avoid the heartbreak of failure in later years—send today for "*Forging Ahead in Business*" . . . one of the most practical and realistic booklets ever written on the problems of personal advancement.

Here you will find—not a "pep-talk," not an academic lecture—but cold, hard *facts* on how to improve your position and increase your income. You will be told what the qualifications of an executive are in today's competitive market . . . what you must *know* to make $15,000, $20,000 or more a year . . . what you must *do* to accumulate this knowledge.

"Forging Ahead in Business" was written for mature, ambitious men who seriously want to get down to bed-rock in their thinking about their business future. If you feel it is meant for you, simply fill in and return this coupon. Your complimentary copy will be mailed to you promptly.



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Circle 420 on Page 19

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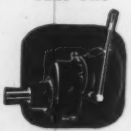
Speed Reducers

ROCKFORD B-W BORG-WARNER

CLUTCHES

trons in the rubidium molecule, and the spin in turn is controlled by the magnetic forces or field.

"We consider this an important scientific advance," said Admiral H. Arnold Karo, director of the Coast and Geodetic Survey. "It gives the geophysicist a new tool. Instruments embodying the principle will be simple, highly miniaturized, and capable of measuring very small magnetic fields—perhaps one billionth of the magnetic force developed by the motor that runs an apartment house elevator. They will be suitable for use in rockets and satellites. One possible application is in planned probes of the moon."

Tube Tells Time For Reliability Studies

Metal-Plating Principle Permits Time Determination

NEW YORK—A time-indicating vacuum tube has been developed to obtain reliability data on components so that lifetimes can be predicted and components changed before failure. The tube, 1½-in. long and ⅜ in. diam, can be incorporated into small, electronic modules to obtain this reliability data. Mechanical timers are impractical for size and economy reasons, and their use must be governed by the voltage and frequency of available sources of power.

The tube, described by W. Eriksen and E. Handly of the Raytheon Mfg. Co. of Waltham and Newton, Mass., at the last IRE National Convention, makes use of Faraday's law of electrolysis—the amount of metal placed onto an electrode is directly proportional to the quantity of electricity passed through the cell.

Called the CK1053, the tube contains an anode and cathode, which are made of an inert material. Operation depends upon passage of a constant direct current through the tube, with a resultant "plating" of the metal ions from the solution onto the cathode. The concentration of metal ions in solution decreases linearly with operating time. The change in concentration is

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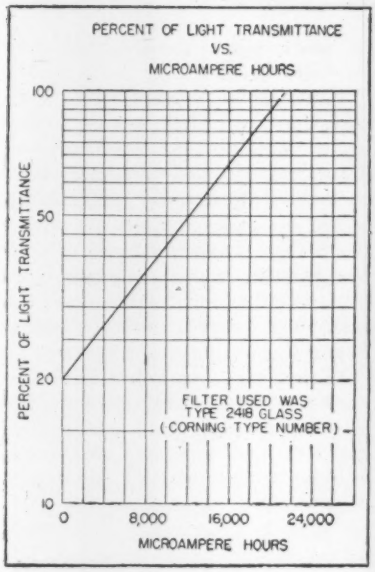

measured by the change in the amount of light transmitted through the solution. The longer the CK-1053 is operated, the more light there will be passed through the solution.

At desired intervals, or at such time as the electronic equipment fails, the CK1053 is removed from the equipment and tested in a colorimeter. The operating time of the component and/or equipment is read from the calibrated scale.

Major applications for the device are expected to be in airborne electronic equipment and in military and commercial computers. The CK1053 could also be used to determine operating time of color TV tubes, magnetrons, klystrons, and transmitting tubes. Suggested general categories of use include the determination of periodic overhaul times, component replacement periods, and warranties of instrument or equipment, and life-test timing.

Build First Water-Cooled Turbine-Driven Generator

SCHENECTADY, N. Y.—Water-cooled stator windings in turbine-driven generators afford the possibility of generator ratings as high as 1-million kva. The General Electric Co. foresees water cooling doubling generator ratings now possible with conventional cooling within the same frame size. Significant savings

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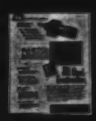
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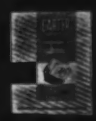
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Circle 422 on Page 19

DIAMOND NEWS ABOUT ROLLER CHAIN DRIVES, APPLICATIONS AND NEW PRODUCTS.

Mathews Engineers use stock Diamond Roller Chain for efficient drives on highly specialized machinery!

Mathews automatic and semi-automatic pallet loaders consist of a series of mechanical, electrical and pneumatic components centrally controlled and coordinated by an electrical system.

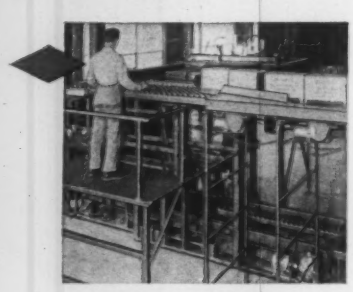
Indicative of sound engineering is the use of standard cataloged Diamond Roller Chain, Conveyor Chain, Attachments and Sprockets for lifting, conveying, power transfer and timing of many operations.

Use of *stock* Diamond Products shortens development time, cuts design costs and lowers production costs. Complete specifications including dimensions, weights, tensile strengths and operating characteristics help both the designer and manufacturer to meet specific requirements.

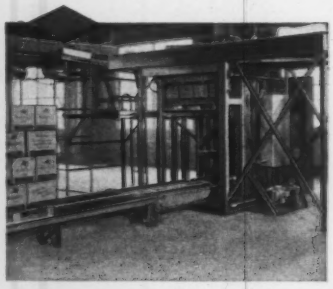
In addition, specialized machines using cataloged Diamond Products have the added sales value of both superior quality and ready availability of parts to guarantee minimum maintenance and down time.

Controlled Gravity Roller Conveyor

Patented Mathews Conveyor controls the speed at which a heavy load will travel down the conveyor line. Diamond Roller Chain drives the rollers to control speed so that the conveyor offers all the advantages of a gravity conveyor plus the full control of a power conveyor.



General view of Mathews Semi-Automatic Pallet Loader handling cartons of motor oil. Multiple strand Diamond Roller Chains support the pallet and its load.



Discharge side of the Semi-Automatic Pallet Loader. Diamond Roller Chains move loaded pallets out to the roller conveyor. At the same time, Diamond Transfer Chains automatically move an empty pallet into position on the full lift platform.

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Mathews Controlled Gravity Conveyor system uses Diamond Roller Chains to control the speed at which heavy loads travel down the conveyor.

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DIAMOND ROLLER CHAINS

in power-plant construction costs are also predicted.

The company's Large Steam Turbine-Generator Dept. is now building the nation's first steam turbine-driven water-cooled generator. Rated at 265,000 kva, the generator is cooled by water circulating through the hollow stator windings. Up to the present, transil oil has been used, but the superior heat-removal ability of water makes possible larger kva ratings of generators.

Water also has other desirable properties, including chemical inertness, low cost, good availability, and its nonflammable character. Hundreds of hours of laboratory tests by the company have indicated no adverse electrolytic or chemical action resulting from the water.

Meetings

AND EXPOSITIONS

Aug. 18-21—

American Society of Mechanical Engineers — American Institute of Chemical Engineers. Heat Transfer Conference to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from ASME headquarters 29 W. 39th St., New York 18, N. Y.

Aug. 19-22—

Western Electronic Show and Convention to be held at the Ambassador Hotel and Pan Pacific Auditorium, Los Angeles. Sponsors are the West Coast Electronic Manufacturers Association and the Institute of Radio Engineers. Further information is available from Don Larson, WESCON, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 3-5—

First National Conference on the Application of Electrical Insulation to be held at the Pick-Carter and Statler-Hilton Hotels, Cleveland. Cosponsors are the American Institute of Electrical Engineers and the National Electrical Manufacturers Association. Further information can be obtained from T. F. Hart,

Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.

Sept. 8-13—

Institute of the Aeronautical Sciences. First International Congress of the International Council of the Aeronautical Sciences to be held at the Palace Hotel, Madrid, Spain. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Sept. 10-11—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 14-18—

American Rocket Society. Fall meeting to be held at the Statler Hotel, Detroit. Further information is available from ARS headquarters, 500 Fifth Ave., New York 36, N. Y.

Sept. 15-19—

Instrument Society of America. Thirteenth Annual Instrument-Automation Conference and Exhibit to be held at Convention Hall, Philadelphia. Additional information is available from society headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 21-24—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Cosmopolitan Hotel, Denver. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 22-23—

Steel Founders' Society of America. Fall Meeting to be held at The Homestead, Hot Springs, Va. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 22-24—

Institute of Radio Engineers. National Symposium of Telemetering to be held at the Americana Hotel, Miami Beach, Fla. Additional information from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

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Sept. 22-24—

Standards Engineers Society. Seventh Annual Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Further information can be obtained from Mr. C. W. Bowler, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.

Sept. 23-26—

Association of Iron and Steel Engineers. Iron and Steel Exposition and Convention to be held at the Public Auditorium, Cleveland. Further information can be obtained from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 29-Oct. 3—

Society of Automotive Engineers. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at the Ambassador Hotel, Los Angeles. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 13-14—

Fifth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Further information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

"Experience? Chief Engineer."

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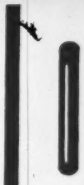
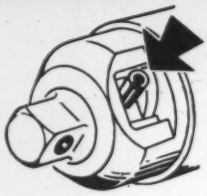
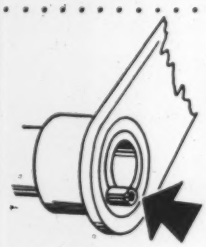


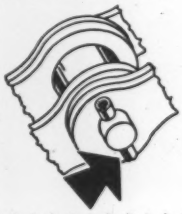


REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.

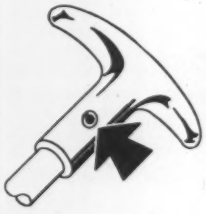


REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.

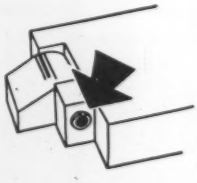
REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.



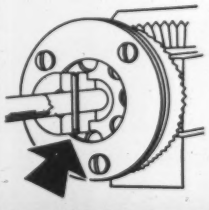
REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.



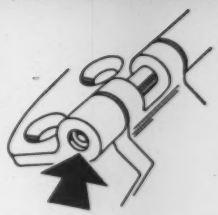
REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



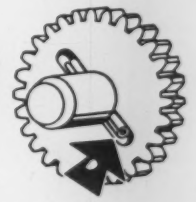
REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



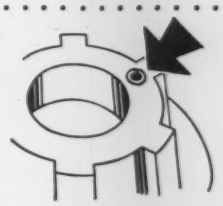
REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.



REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.

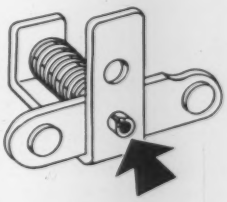


REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



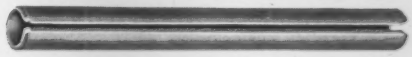
REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.

REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?



Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

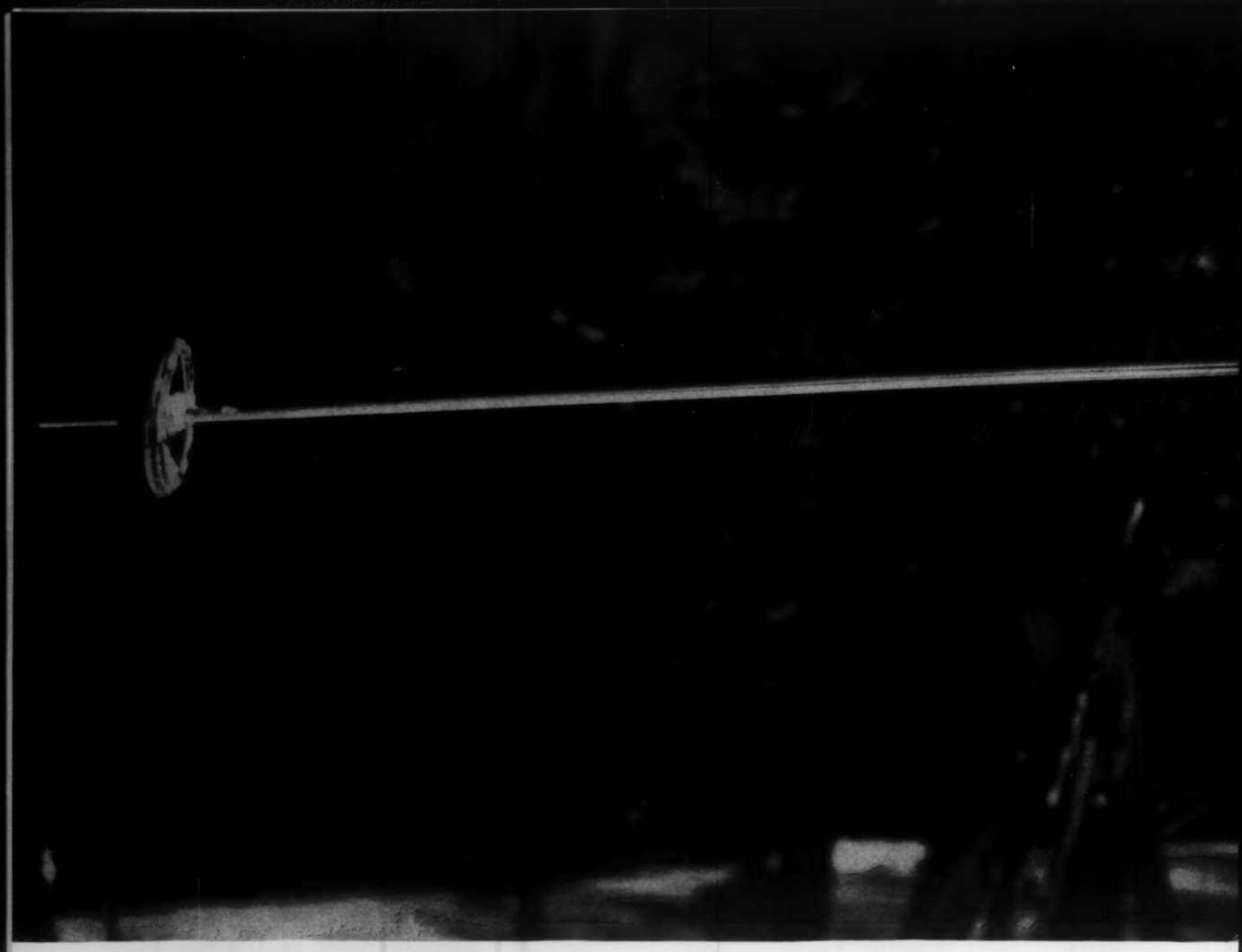
Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-84, Union, New Jersey.

Circle 426 on Page 19

ROLLPIN TRADEMARK

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 VAUXHALL ROAD, UNION, NEW JERSEY



Lightness—There are a few products in this world that you don't want to be light—like pile drivers, dumbbells and paper weights. But generally speaking, every designer strives for the lightest product that will do the job, especially in things like truck trailers and off-highway earthmoving equipment (the lighter the unit, the greater the load capacity) and in structures like a bridge, which has to support itself *and* a roadbed.

Lightness is easy to attain. For instance, you could make a ski pole out of balsa wood, rather than the Stainless shown above, and never know you were holding it. But almost always as we strive for lightness, we also demand a certain amount of stiffness, ductility, strength. More than that, we need a material that can be fabricated on high-speed machinery.

So it's interesting to note that today, in cases where lightness is absolutely vital and *hang the cost*, designers still turn to steel rather than costlier materials when they need low weight and high performance.

When our Explorer I satellite screamed into outer space, it was cased in Stainless Steel. On every high-performance aircraft, the landing gear is made from ultra-strong steel because each single pound shaved from the landing gear assembly saves from 7 to 10 pounds of total aircraft weight, since it reduces the wing area, thrust and fuel required for the specified performance. Today, as we prepare for the first exospheric manned flight, we are completely sheathing the fuselage in steel, because no other available material has a better combination of lightness and high temperature strength.

In new, light-weight bridges, designers automatically think in terms of the new alloy and high strength steels. They're so strong that thinner, lighter sections can be used, and they have the extra atmospheric corrosion resistance necessary.

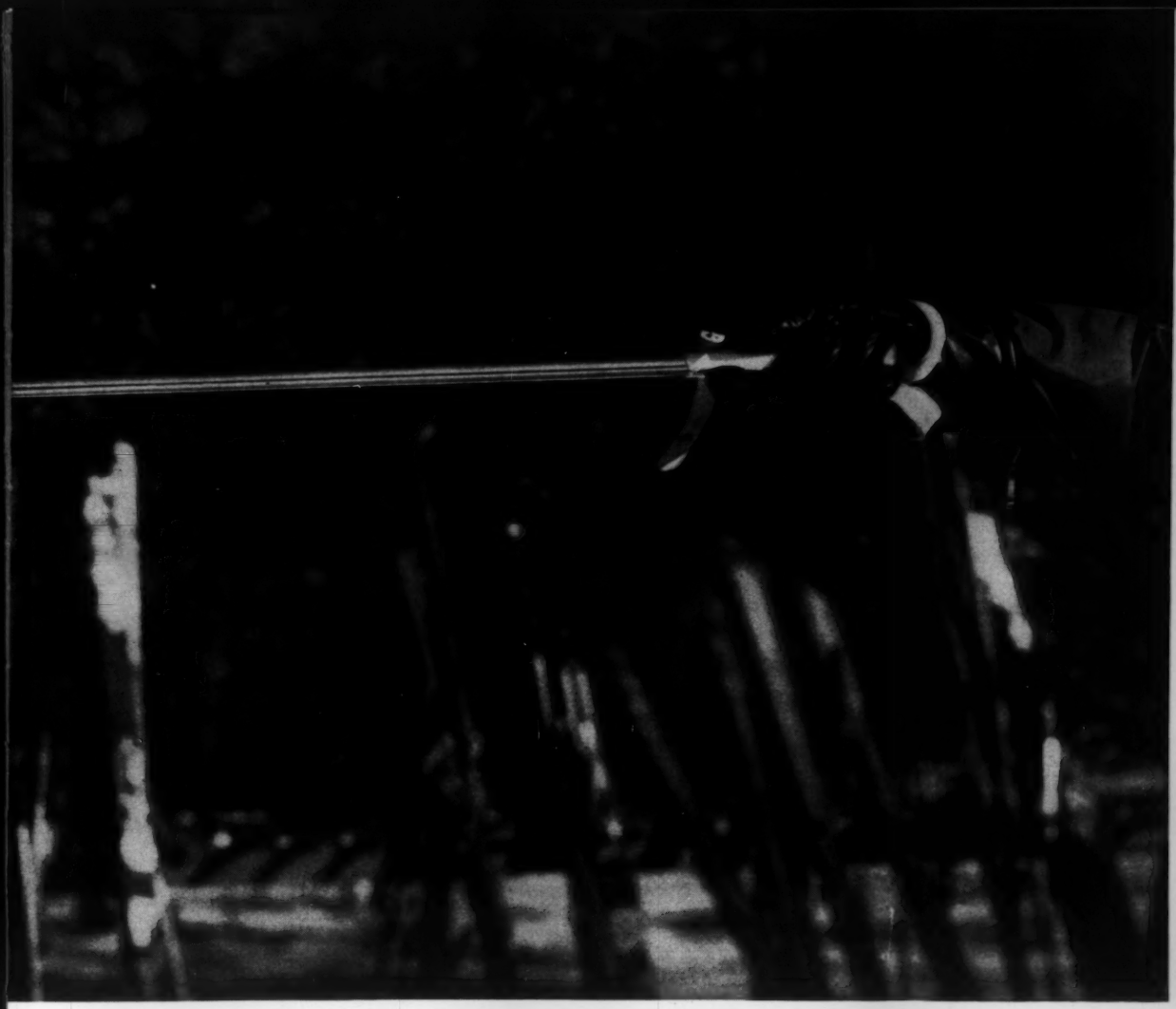
The new steels should be chosen and fabricated with care, and the final selection should be made by a skilled metallurgist—either on your staff or ours. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube • Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STEELS FOR DESIGN



Lower Left—Problem: Design a trailer to haul more coal and stay within the legal highway weight limit. Solution: Marion Metal Products Company used USS COR-TEN High-Strength Low-Alloy Steel to build a bigger trailer that is lighter because the stronger steel can be used in thinner sections. Payoff: The new units weigh 23% less than the old, have a 50% greater payload, and gross weight is *still* within the legal limit.

Lower Middle—Problem: Build a 40-ton-capacity bottom dump trailer that would have the highest payload-to-weight ratio ever obtained. Solution: Athey Products Corporation designed the unit with USS "T-1" Constructional Alloy Steel which combines a minimum yield strength of 100,000 psi with weldability and remarkable toughness. Payoff: New trailer weighs 11,000 pounds less than conventional construction and hauls payload over 3½ times its own weight.

Lower Right—Problem: Replace 550-bbl. fermentation tanks with new tanks of same capacity but light enough to hang from the ceiling. Solution: Chicago Steel Tank chose Type 304 Stainless Steel and a unique new design utilizing Stainless Steel's strength and formability. Payoff: New tanks weigh only one-fourth as much as the old and have identical capacity.

USS, COR-TEN and "T-1" are registered trademarks

PRECISION "O" RINGS

Quality proved by all ASTM Tests

Precision "O" Rings made from Compound 830-70 meet or exceed all the SAE 120-R requirements for heat, oil resistance and other properties.

100% better compression set. Remarkable superiority in 300° F hot oil. 100% better Fatigue Test life.

For manufacturers of automobile, machine tool, farm equipment and similar equipment, Precision Compound 830-70 is your answer to positive long sealing life.

Have a sealing problem? You'll find the answer at Precision! There's a Precision engineer ready to help you.

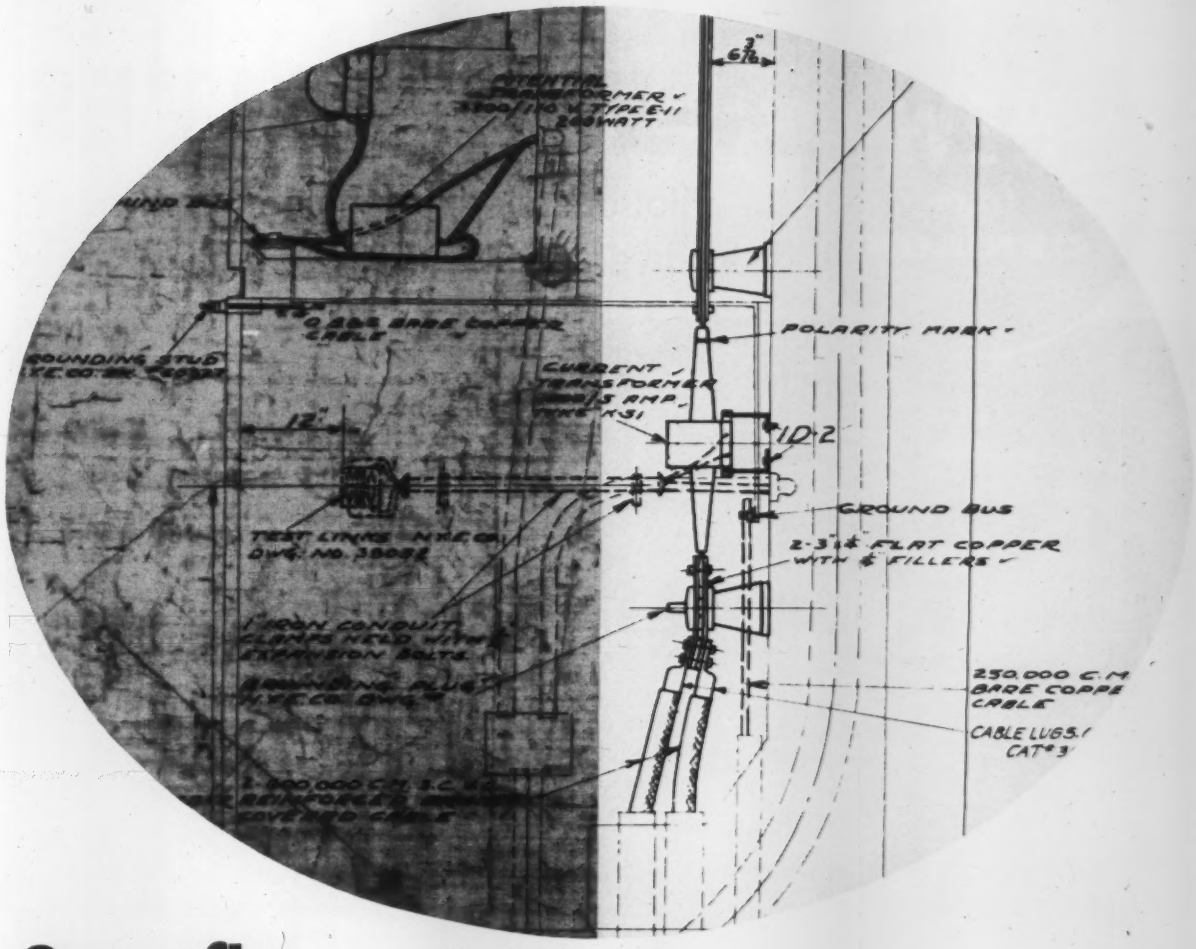
Get your free copy of our engineering data sheet on Compound 830-70.

Specify Precision—first in Quality

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Thérése de Blainville, Québec**



Cronaflex prints clean:

TRADEMARK

Eliminates kinks, smudges, creases from original drawing

Examine these two prints. The one on the left, on cloth, bears the same scars of age and wear as the old original drawing. The copy on the right, made from the same original, is on CRONAFLEX. See how CRONAFLEX has eliminated the kink marks, cleaned up the smudging—actually improved the drawing.

Corrections can be made right on your CRONAFLEX copies . . . in either pencil or ink. Even photographic lines can be removed, then corrected, *on either side of the film* because CRONAFLEX is double-matted.

Your drawings on CRONAFLEX are rugged. They can be used to make literally hundreds of copies on standard reproduction machines. Also, your CRONAFLEX copies will not smear or discolor with constant handling, like cloth does.

For more information on this new line, see your Du Pont Technical Representative, or write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

This advertisement was prepared exclusively by Phototypography.

DU PONT
REG. U. S. PAT. OFF.

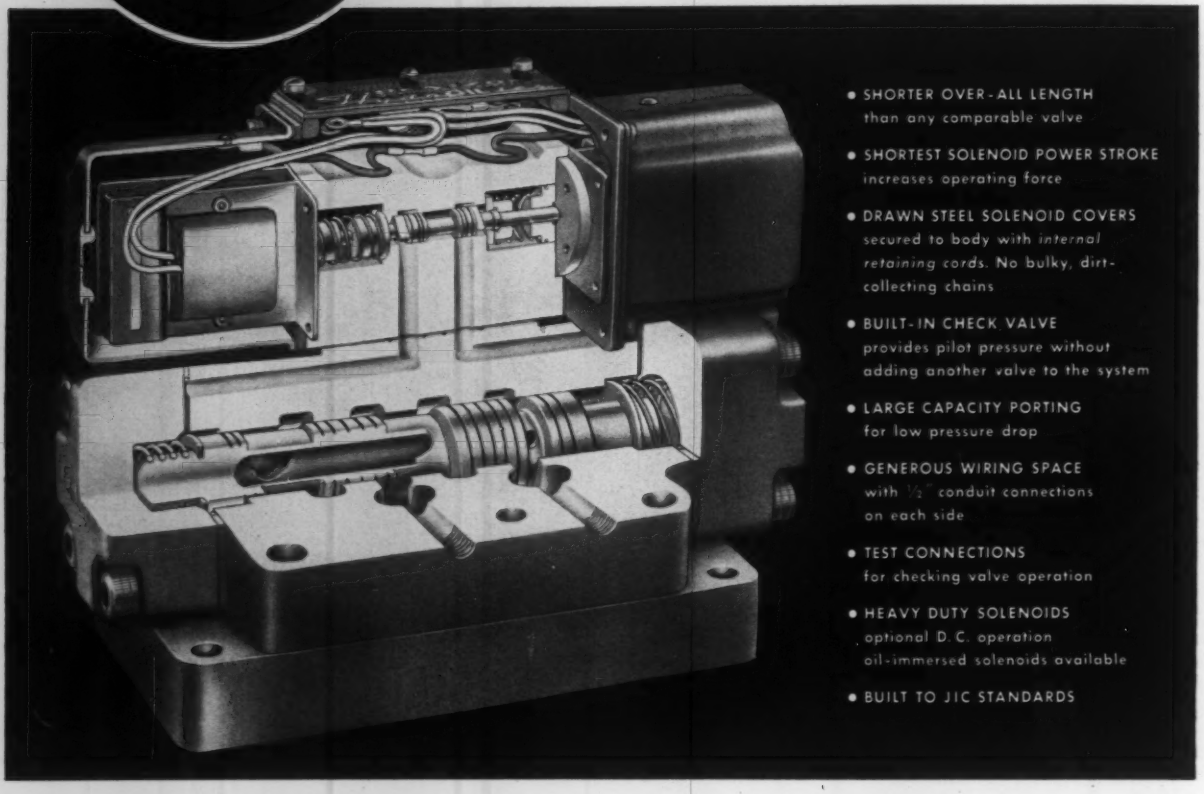
Better Things for Better Living . . . through Chemistry

Circle 428 on Page 19

NEW from DENISON

4-WAY VALVES

Pilot-operated, solenoid-controlled for hydraulic systems up to 5000 psi



- SHORTER OVER-ALL LENGTH than any comparable valve
- SHORTEST SOLENOID POWER STROKE increases operating force
- DRAWN STEEL SOLENOID COVERS secured to body with *internal retaining cords*. No bulky, dirt-collecting chains
- BUILT-IN CHECK VALVE provides pilot pressure without adding another valve to the system
- LARGE CAPACITY PORTING for low pressure drop
- GENEROUS WIRING SPACE with ½" conduit connections on each side
- TEST CONNECTIONS for checking valve operation
- HEAVY DUTY SOLENOIDS optional D. C. operation oil-immersed solenoids available
- BUILT TO JIC STANDARDS

SHOCKLESS HYDRAULIC CONTROL for any directional control requirement is assured with Denison's new line of 4-Way Valves.

Here are *more reasons why* the exceptional design versatility of these new 4-Way Valves is important to Hydraulic Engineers—

1. Provide fast, rapid-cycle directional control of hydraulic flows up to 30 gpm.
2. Operating pressures range up to 5000 psi for both ¼" and ¾" valve sizes.
3. Operate in any porting and positioning combination.
4. Solenoid-operated ¼" valve capacity—5 gpm.
5. Pilot-operated, solenoid-controlled ¾" valve capacity—30 gpm.
6. Choice of spool types and spool positioning provides unlimited combinations for a wide range of applications.
7. Adjustable pilot chokes available for smooth spool reversal.
8. Interchangeable parts simplify service and model changes in the field.
9. Easily modified for operation on internal or external pilot pressure by rotating solenoid valve 180°.

DESIGNERS ENGINEERS!

Send for Bulletins VD-7, VD-8 and 240-B

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

for full details write

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DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

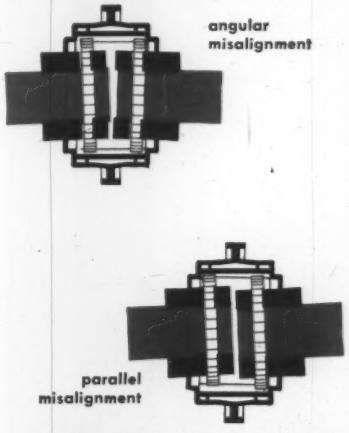
LINK-BELT motor couplings...

geared for top economy and long wear

NEW!

Durable, lightweight design consists of two externally geared steel hubs, which engage flexibly with an internally geared steel sleeve — all enclosed in a protective two-piece metal cover. Synthetic rubber O-rings and felt hub seals effectively retain lubricant and exclude outside contamination.

Misalignment protection



Link-Belt Motor Couplings accommodate free angular and parallel misalignment.

Now you can afford flexible geared couplings on small electric motor applications. New Link-Belt MC motor couplings are *geared* couplings—the established standard of performance throughout industry. And at a new *low price*, these couplings are no longer too expensive for smaller motor applications.

High capacity and durability are embodied in the all-metal design. Assembly or disassembly is quick and easy . . . fast-acting quarter-turn spiral cam fasteners are a permanent part of the cover. No loose nuts or bolts.

Equipment manufacturers will discover special economies in Link-Belt MC couplings—they are excellent for such equipment as speed reducers, pumps and generators. Available "off-the-shell" for shafts up to 1⅞".
Contact your nearby Link-Belt office.

Write for Folder 2875—Gives detailed information and specifications on the new Link-Belt MC motor coupling.

14,950

LINK-BELT

GEARED FLEXIBLE COUPLINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

Circle 430 on Page 19

FOR THE MACHINERY PART

THAT TAKES THE BEATING

A cut-off knife made of HAYNES STELLITE alloy No. 19 slices through molten glass at 2200 deg. F. Despite the intense heat of the glass being molded into tumblers, and the severe erosive action of the glass on metal, the cut-off knife maintains a 0.015-in. clearance between itself and the mold ring . . . *far longer than any other material ever used.*

Are you looking for a tough metal part to improve your machinery? It will pay you to look into HAYNES alloys. There are more than 15 from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. Parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist many conditions of wear, heat, or corrosion.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

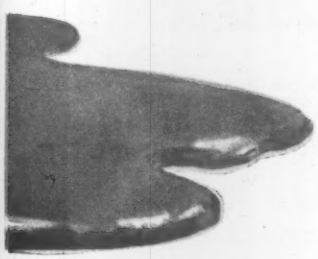
Division of Union Carbide Corporation

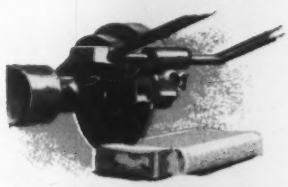
Kokomo, Indiana

UNION CARBIDE

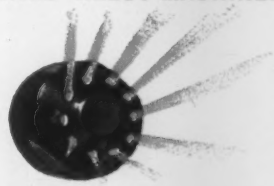
The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS





Tough, long-lasting metal-cutting saws over 20 inches in diameter, made of HAYNES STELLITE alloy sheet, slice the tops off copper ingots.

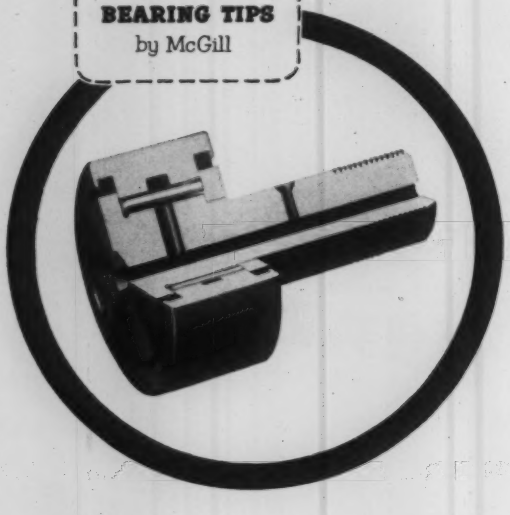


Steam atomizer fuel burner nozzles of HASTELLOY alloy C resist corrosive agents and erosion for months, retaining essential contours.

High-temperature strength and corrosion resistance of diesel combustion chambers made of HASTELLOY alloy C make them "good for life of the engines."

Circle 431 on Page 19

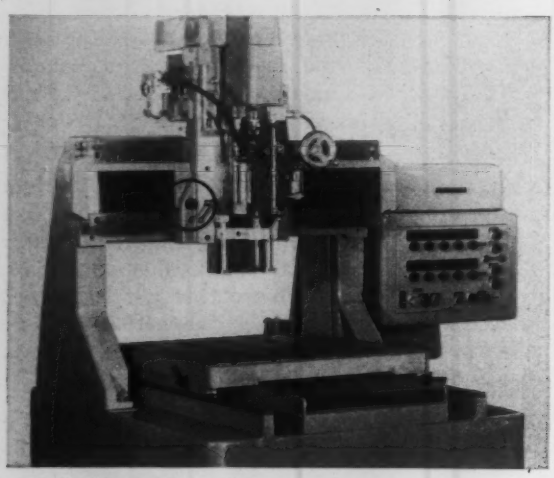
BEARING TIPS
by McGill



McGILL sealed CAMROL® bearings protect roller follower efficiency — prelubricated to reduce maintenance

Sealed SCF series bearings add protection from contamination to the extra performance advantages of McGill CAMROL cam followers. Specially treated labyrinth seals at the roller ends keep out moisture, dirt, chips, etc. All exposed surfaces are treated to provide a corrosion resistant black ferrous oxide finish.

The sealed construction with a channeled grease reservoir in the outer race bore eliminates need for frequent relubrication. Maintenance is reduced and can be eliminated in inaccessible mountings. Specify standard bearings and avoid building up followers with extra seals.



Sealed CAMROL bearings as table and crosshead rollers in tape-controlled Hillyer drilling machine

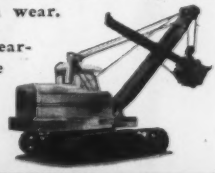
CAMROL bearings provide smooth, accurate motion as load carrying rollers for table and crosshead motion of this tape-controlled, precision drilling machine manufactured by HILLYER CORPORATION. Use of these bearings has simplified construction and improved accuracy. They have eliminated the manufacture of shaft and retainer assemblies and increased load capacities. The corrosion resistant finish has also eliminated the need for plating bearings. Ball bearings formerly used cracked under the same loads. Operating speeds are 400 RPM and loads are 2000 pounds. The bearings are prelubricated and sealed to keep maintenance at a minimum.

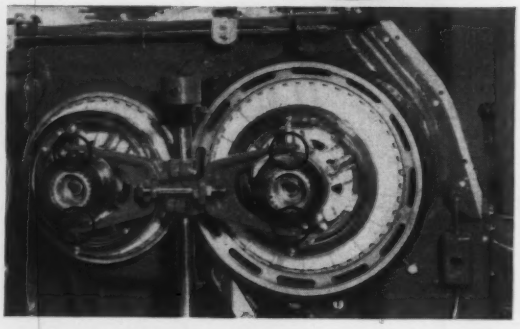
Sealed CAMROL bearings replace bronze rings in shovel clutches

UNIT CRANE & SHOVEL CORPORATION is using SCF SEALED CAMROL bearings in clutch shifter yokes in their ½ and ¾ yard power cranes and shovels and Model 360 MARINER 30-ton cranes. Shown is a closeup of two of the five clutches which control the hoist drum and the hold drum and various actions of the machines. The bronze collars formerly used were higher in initial cost than the CAMROL bearings. Their use also required considerable machining and the addition of component parts such as bolts, spacers, etc.

The CAMROL bearings in this application promise better, more accurate control than the bronze shifter rings which tend to become "sloppy" with wear.

The integral seal feature of the bearings protects their performance under field conditions and reduces relubrication requirements.





engineered electrical products

McGILL®

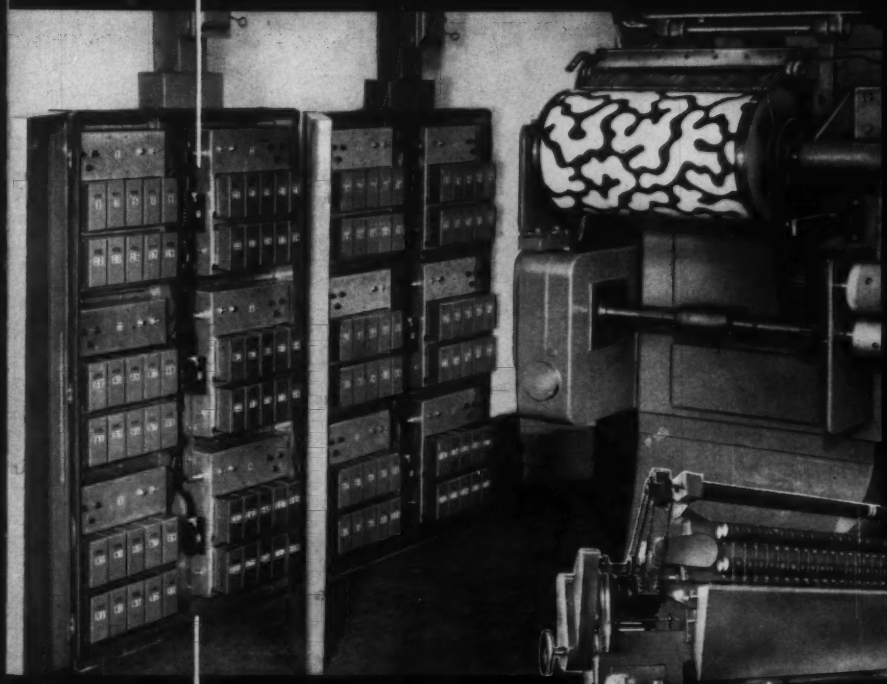
precision needle roller bearings

SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Reliability



Yarn control of the Cobble Bros.' Tufting Machine is through electrical contact fingers which transmit impulses to 120 CLARE RELAYS each controlling two electro-magnetic clutches.

That's why

COBBLE BROS.' controls were designed around Clare Relays

"The most important reason Clare Mercury-Wetted-Contact Relays were chosen as the basic components for this control is their *reliability*."

Assurance of billions of trouble-free operations caused engineers of Cobble Bros. Machinery Co. to design their electrical control system around Clare HG relays.

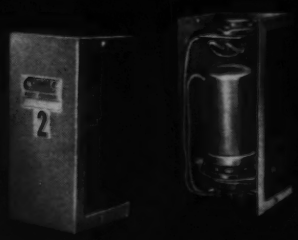
There are 120 Clare HG Relays in controls of the Cobble Yardage Tufting Machine shown. They receive impulses from 120 electrical contact fingers as they "read" the pattern. The relays operate electro-mechanical clutches to translate these impulses into intricate carpet designs.

Reliability means freedom from costly maintenance. If, like Cobble Bros.' engineers, you want only the best for your design, let us tell you ALL about Clare Mercury-Wetted-Contact Relays. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

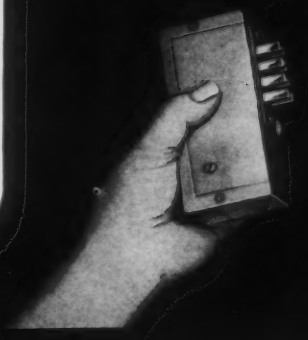
Circle 433 on Page 19



Each relay is housed with a transistor in this modular type unit. The module is then plugged into the control system.

• • •

Send for Clare Bulletins 120 and 122



HOW CAN YOU USE THIS NEW TYPE OF

ArmaSteel®

Tensile strength, 105,000 • Minimum yield, 85,000 • Minimum elongation in 2", 2% • Brinell hardness 269-302, (3.5-3.7 mm)
Machinability 20% better than steel of same hardness!

ARMASTEEL 88M has been developed to fill the automotive industry's needs for a material having increased wear resistance and high yield strength, yet at the same time retaining good machine characteristics.

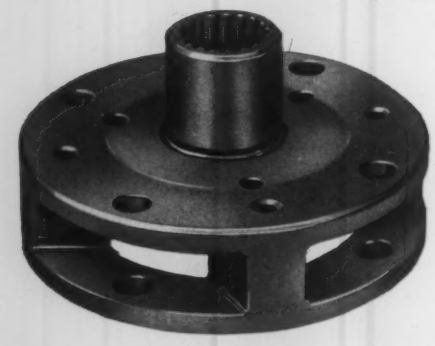
ARMASTEEL 88M does not require heat treating and thus relieves customer facilities or eliminates capital expenditures. In many parts, distortion is a problem after heat treating. Parts made from ArmaSteel 88M can be machined without further heat treatment and still give good wear resistance.

This new castable metal is a pearlitic malleable iron which possesses substantially the same strength and the same wear characteristics as alloy steel forgings. Being a castable material, it has the two advantages of design flexibility and good machinability. Why 88M possesses these characteristics—and how it will fill the needs of American industry will be of interest to manufacturers and engineers in many fields . . .

PRODUCTION OF 88M—By accurately controlling the heat-treatment of ArmaSteel 88M in controlled atmosphere furnaces at 1750° for approximately 15 hours, all massive carbides are removed. This heat treatment is followed by closely controlled oil quench and tempering operations to provide a narrow range of hardness.

Universal Joint Yoke

Automatic Transmission Planet Gear Carrier



Surface hardening of ArmaSteel, if desired, does not require carburizing. Instead, flame-hardening, induction-hardening or simple immersion methods may be used. A surface hardness of 50 Rockwell C to 60 Rockwell C can be readily obtained. Wear-resistant properties in the hardened area are comparable and sometimes better than carburized steel, while the remaining sections retain their original toughness.

MACHINABILITY—In addition to performance characteristics, ArmaSteel offers good machinability. Carbon spots that are present in the Matrix of ArmaSteel allow the chips to break off readily, effectively reducing machining time and prolonging tool life. In comparative tests, ArmaSteel shows itself to be a more freely-machining material than steel bar stock or forgings of the same Brinell hardness.

Because of its ability to assume the shape of practically any molded cavity, 88M not only permits great

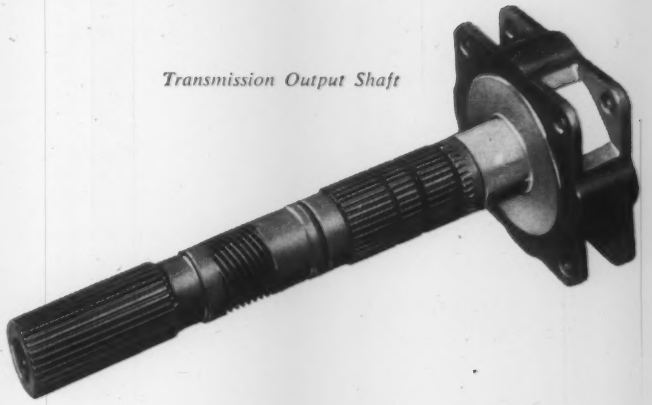
81

PEARLITIC MALLEABLE IRON?

88 M *developed by*

CENTRAL FOUNDRY DIVISION

Transmission Output Shaft

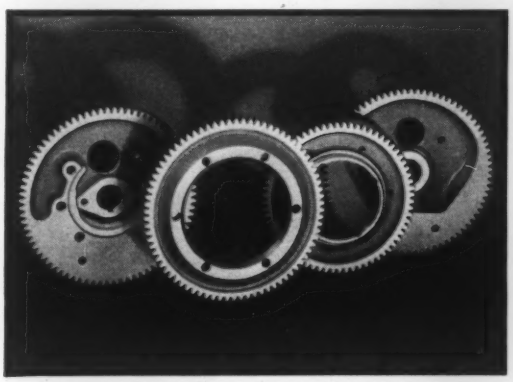


freedom in design but also possesses certain inherent physical characteristics not present in forgeable alloys.

APPLICATIONS—ArmaSteel 88M is now being cast for automatic transmission planet gear carriers and universal joint yokes for leading automobile manufactures. Other interesting applications now in the testing stage include transmission output shafts, and diesel engine idler, balance and crankshaft gears.

Just what hundreds of other applications are in store for 88M is still anyone's guess. But the more one examines its characteristics, the more it would seem that it will fill many needs in many types of products and industries. In your products, for example, you may well see where 88M could both improve performance of components subject to great wear or great stress, and at the same time reduce final cost because of the economy in casting and the economy in a material with superior machining characteristics.

Diesel Engine Idler, Balance and Crankshaft Gears



CASTING—Parts are cast in ArmaSteel 88M, here at Central Foundry Division, in either standard green-sand molds or the newer, more precise shell-molds. In addition to 88M, Central Foundry Division produces castings, on a volume basis, in grey iron, alloy grey iron, malleable iron, and ARMASTEEL 84M, 85M and 86M.

Our research facilities and engineering staff are prepared to help you determine whether 88M or any of the other materials now being cast at Central Foundry will fill your needs or help you reduce your over-all product cost.

Write for your copies of our two comprehensive manuals, "ARMASTEEL" and "SHELL CASTINGS."

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Circle 434 on Page 19

NEW...

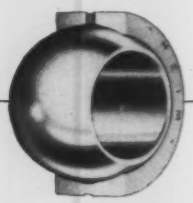
POWDER METALLURGY TECHNIQUE FOR PRODUCING Unibal®

2 PIECE SPHERICAL BEARING

A brand new innovation in spherical bearing design

Through a series of controlled thermal, physical-chemical, and mechanical steps, the balls are made of high density, through-hardened powdered iron alloy, and the outer members are made of sintered iron or sintered bronze with controlled porosity.

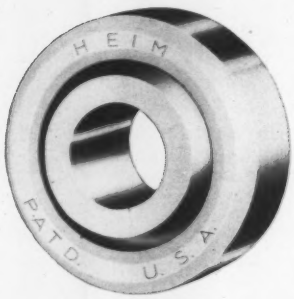
Pressing and sintering procedures make it possible to produce a bearing which will hold up to 20% of its own volume in oil. This means longer bearing life with less frequent relubrication required. Manufacturer's tests on a 5/16" bore bearing at 1350 rpm with a 30 lb. load ran for 2000 hours with only weekly relubrication.



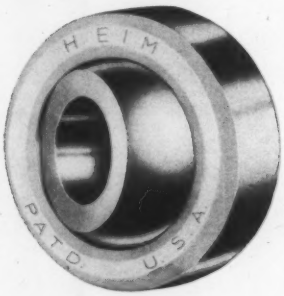
This cutaway view of the Unibal 2-piece spherical bearing shows how a coined (or swaged) type bearing presents a large surface-supporting area, and is capable of rotating so as to correct shaft misalignment in all directions.

Heim has been a leader in spherical bearings since their original development — an old hand with new ideas. This skill and experience can solve problems — and save money — on YOUR bearing requirements. Just call the nearest Heim bearing distributor or write direct for catalog or engineering assistance.

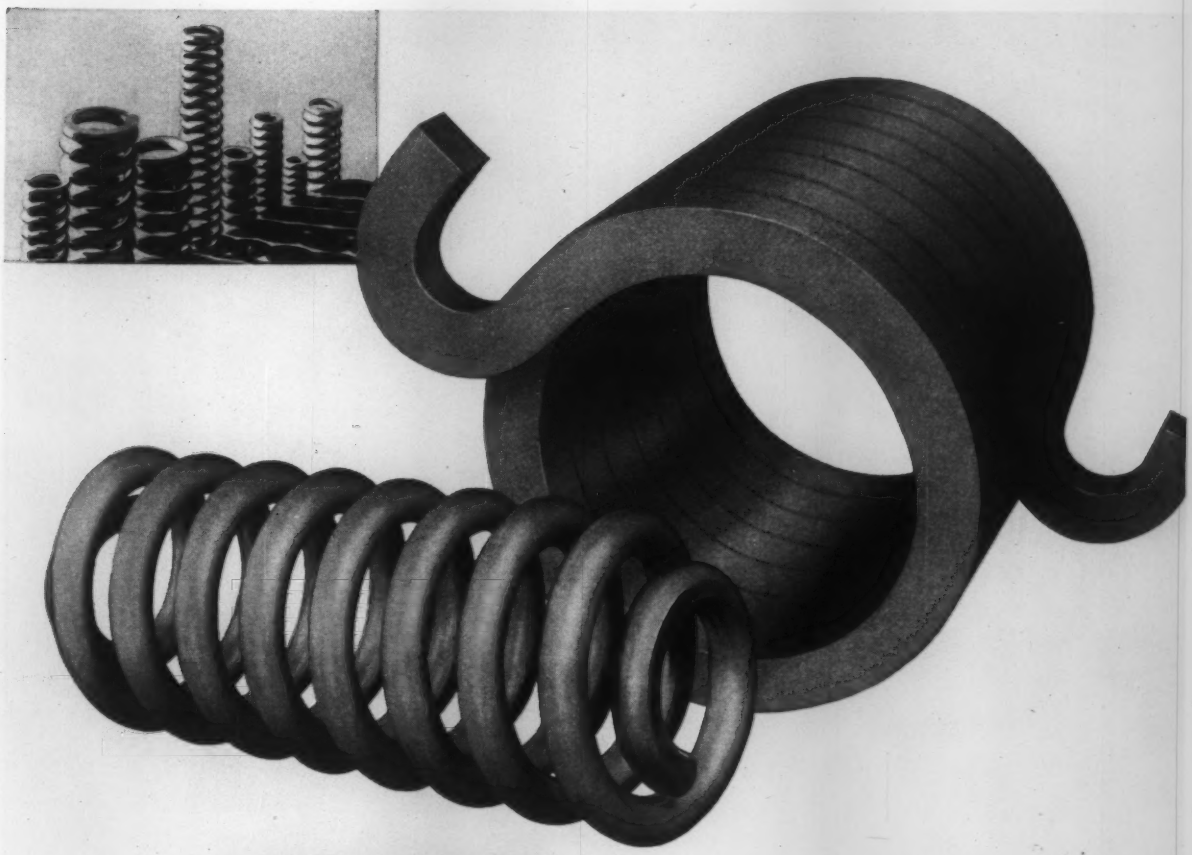
THE HEIM COMPANY
FAIRFIELD, CONNECTICUT



These new Unibal spherical bearings of sintered metal cost less than comparable bearings of conventional materials.



Like all Unibal spherical bearings and rod ends, the new 2-piece bearing produced by powder metallurgy, will correct misalignment to the maximum degree.



CRUCIBLE FATIGUE-RESISTANT SPRINGS

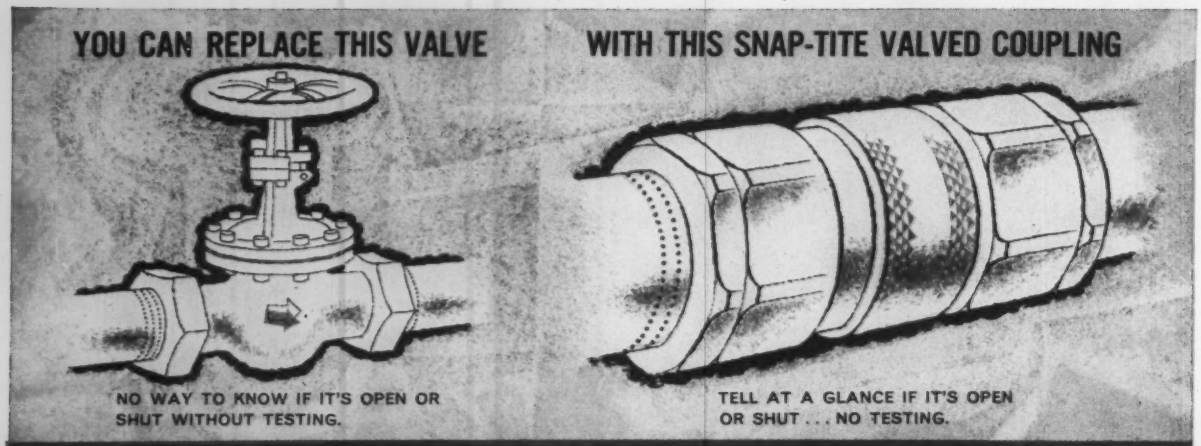
"made stronger to last longer"

Crucible *fatigue-resistant* springs have far greater durability than ordinary springs. Furthermore, these springs, section for section, can take heavier compressive, tensile or torsional loads than ordinary springs. That's because they're *shot peened.* This process imposes a compressive stress on the spring surfaces that offsets stresses set up in service. It also conditions the surfaces, and eliminates minute stress concentration points which could lead to premature failure in a conventional spring.

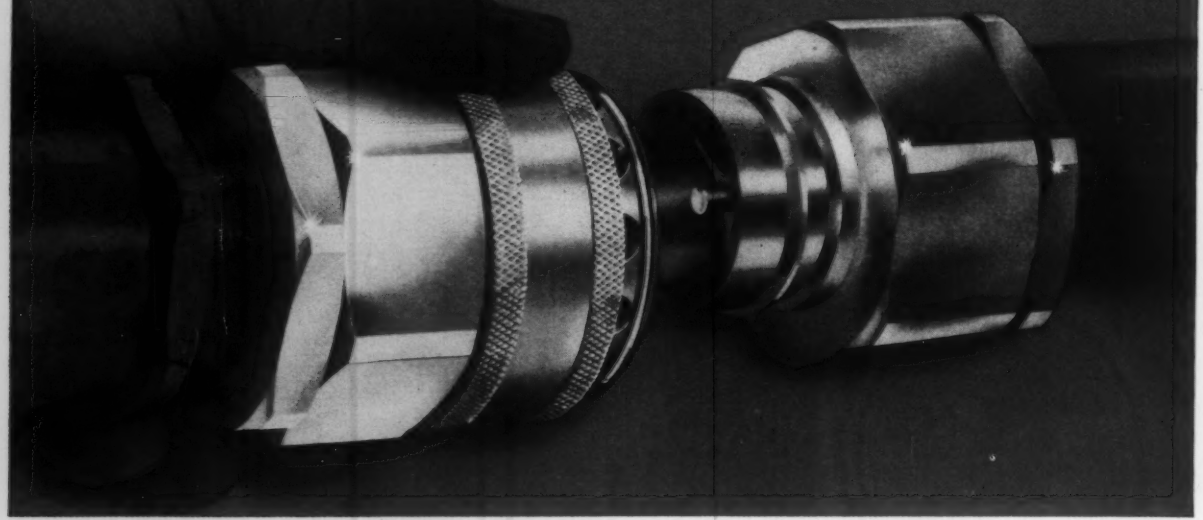
Try Crucible *fatigue-resistant springs* for lighter springs of improved design, greater precision and longer service life. For complete details, send for the Crucible "Coil Spring Design" handbook. Ask a Crucible spring specialist to call, too. Write: *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE HEAVY-DUTY COIL SPRINGS

Circle 436 on Page 19


YOU CAN REPLACE THIS VALVE
WITH THIS SNAP-TITE VALVED COUPLING
NO WAY TO KNOW IF IT'S OPEN OR SHUT WITHOUT TESTING.
TELL AT A GLANCE IF IT'S OPEN OR SHUT . . . NO TESTING.

A CHALLENGING NEW CONCEPT- AUTOMATIC VALVING



The *instant* the two halves of the Snap-Tite valved coupling are connected there is full, free flow through it. No tedious turning of wheels as in conventional valves. When you want to shut off the Snap-Tite valved coupling, you just pull back the sleeve. You can tell at a glance the line is closed.

Leakage past conventional valves is difficult to find . . . not so with Snap-Tite valved couplings! Further, Snap-Tite valved couplings take up less space. So, why not switch to Snap-Tite automatic valving? Eliminate the possibility of incorrectly set or leaking valves and save time in installation and maintenance. Investigation might show considerable savings.

Sizes ¼" to 10" of all machineable metals

For more information, write for Snap-Tite catalog and, if you wish, outline your problem. Your local Snap-Tite representative will be glad to advise you.

SNAP-TITE COUPLINGS CAN HANDLE ALMOST ANYTHING THAT FLOWS

★Snap-Tite, INC.

UNION CITY 11, PENNSYLVANIA

Circle 437 on Page 19

ALLWAY TOOLS uses fewer parts and cuts production costs with die castings

CASE HISTORIES FROM MT. VERNON FILES

"We set out to make the best looking–best performing–best priced line of woodscrapers on the market. Die casting helped us do it", reports Mr. Gringer, President, *Allway Tools.

There's no doubt about it—Allway 4 Edge Wood Scrapers for fine and rough work, and Allway Finishing Scrapers for fine work are easily one of the best designed and easiest performing scrapers available. And a vital factor in their design and manufacture has been the full use of all the inherent advantages of zinc die casting.

Each blade mount is a light-weight, rigid, ribbed casting of great strength. Allway Scrapers have to withstand lots of hard pressure without bending or cracking.

All design requirements, mounting bosses, correct curvature for effective blade angle, clean edges and finish, high production rate, were economically achieved. In addition to their quality design and construction, Allway Scrapers have to be competitively priced.

Allway takes the zinc die castings as they come in – drills and taps a hole or swages a rivet stud as required in each model – firmly stakes a steel handle to it – adds blade and vinyl grip, and the scraper is ready for market. Result – simplified, fast, low-cost production and a superior product.

When you are confronted with problems of lower production costs or product improvement, consider die casting and bring your problem to us. Our complete four-fold service will help provide the answers. Contact your nearest Mt. Vernon sales representative for quick action.

*Allway Manufacturing Co., N. Y. C.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

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LUTHERVILLE, MD.: Mr. C. McIntosh Gordon, Mays Chapel Rd.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
BROOKLYN, N. Y.: Robert V. Moore, 2317 Plumb 2nd St.
EAST ORANGE, N. J.: Mr. George E. Habl, 39 So. Munn Ave.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115
BOSTON, MASS.: Mr. James Cleary, 61 Exeter Street

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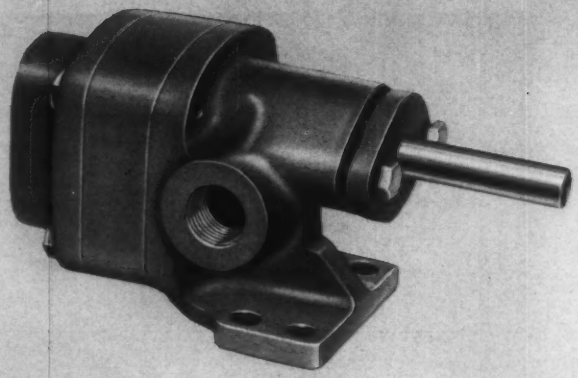
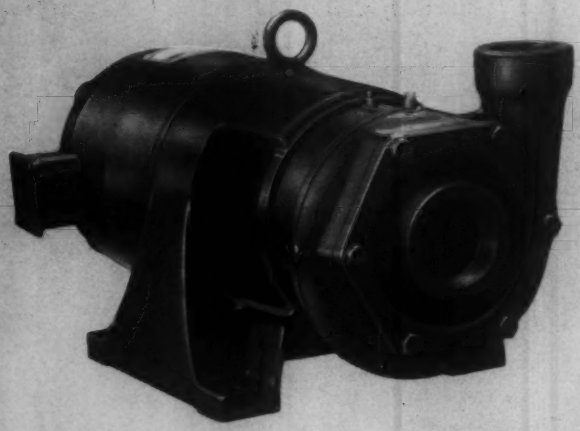
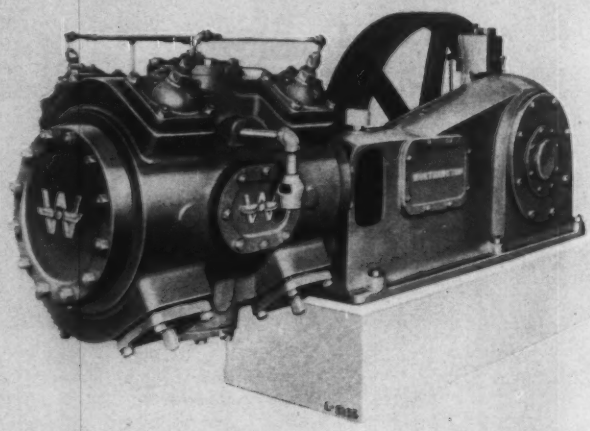
Monobloc Rotary Pump



Rotary Pump



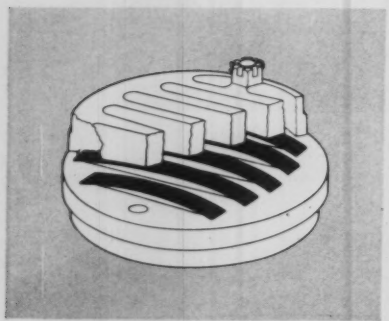
Monobloc Centrifugal Pump



Water-cooled Compressor

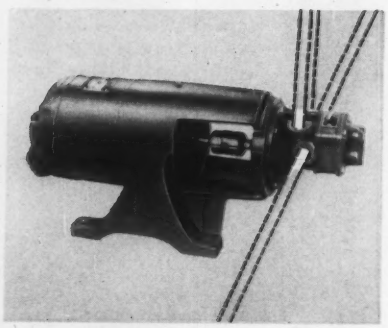
On any pump or compressor you choose, only Worthington gives you these

EXCLUSIVE

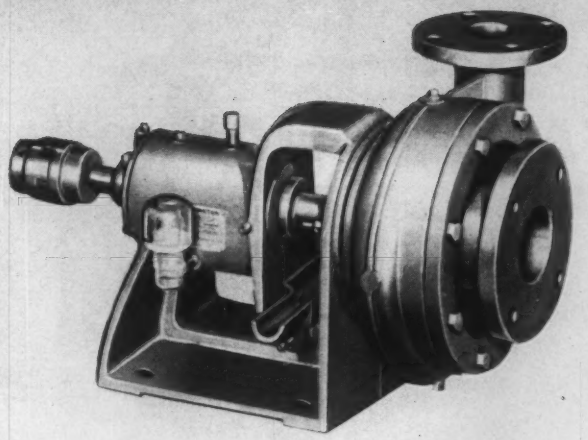


Feather Valve Lightest, fastest-acting compressor valve available. Works with no impact, is all but indestructible, and has an amazing record of long life with negligible maintenance costs.

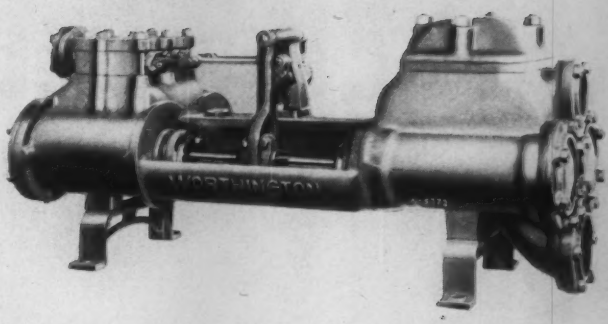
70,480 Combinations Completely standard and interchangeable components let you save up to 50% on spare parts inventory, permit you to design and build over 70 thousand "special" pumps using but 6 SESC pumps.



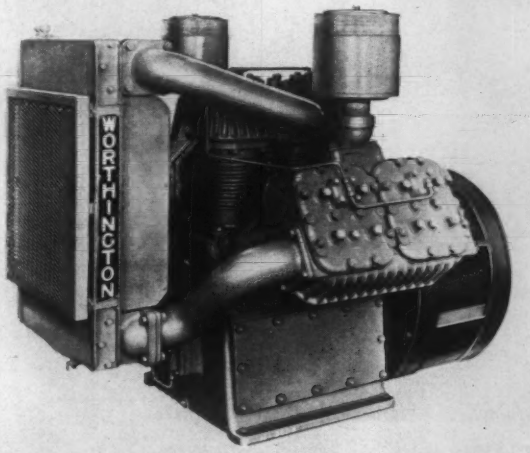
Monobloc Rotary Pump Eliminate alignment problems, simplify layouts by choosing up to 28 different ways to hook up pump piping. Saves you time, materials, is less expensive than separate pump, motor and baseplate.



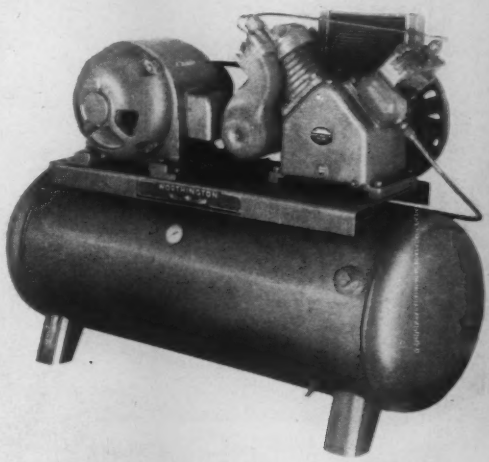
Chemical Centrifugal Pump



Steam Pump



Radial Air-cooled Compressor



Balanced Angle Air-cooled Compressor

DESIGN ADVANTAGES

Designing and manufacturing outstanding products has been a success story typical of Worthington for 118 years. Foremost examples of this leadership and engineering skill are the exclusive design advantages of Worthington pumps and compressors. Three of the most important are illustrated at left: Feather Valves*, Monobloc Rotary pumps, and the unmatched flexibility achieved through standardization of the SESC (Standard End Suction Centrifugal) line.

Worthite*, Worthington's *super* stainless steel, has set new corrosion resistance standards for chemical pumps. Worthington air-cooled or water-cooled compressors include carefully balanced operating parts, low piston speeds, and liberal cooling surfaces on cylinders and intercoolers or aftercoolers. Increased performance and accessibility of portable and balanced angle compressors and the money-saving benefits of easy installation and low maintenance of the entire pump and compressor line lend further testimony to Worthington engineering competence. But whatever your application, your design problem, Worthington can help you.

Your nearby Worthington representative stands ready to explain the many advantages of one *complete* Worthington pump and compressor line to you. For more information on how to improve your product's performance or reduce engineering design and expense, contact him now. Or write for bulletin, Worthington Corporation, Section 104-7, Harrison, N.J. In Canada, Worthington, Ltd., Brantford, Ontario.

WORTHINGTON

*A high-nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U.S. Pat. Off.

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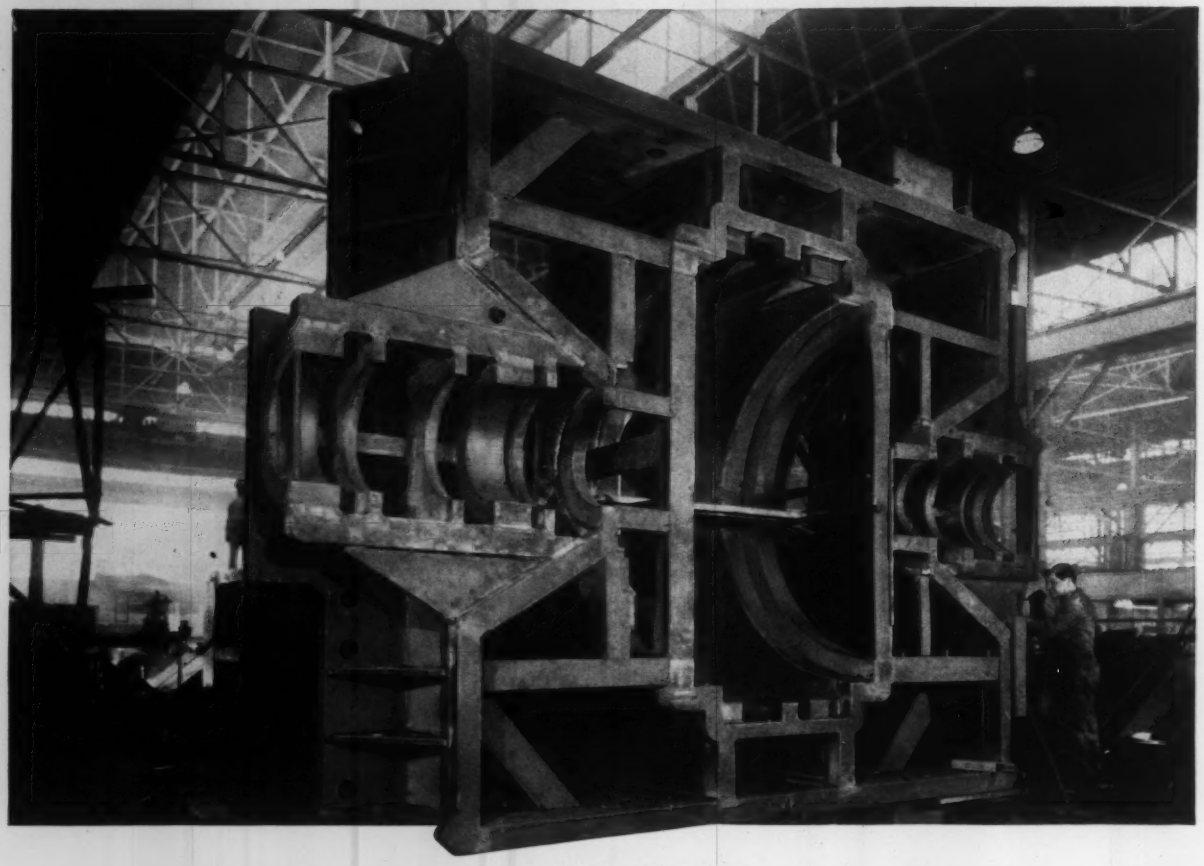
STEEL-WELD FABRICATION . . .



Less Weight in Heavy Machinery Components!

The 100-Ton Weldment illustrated above, in process of fabrication, is the base unit of a housing for a 300,000 kw Steam Turbine. It is a typical example of Mahon's capabilities in the field of heavy plate fabrication.

When you consider Steel-Weld Fabricated components for processing machinery, machine tools, or other types of heavy mechanical equipment, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

Use WELDED STEEL for 100% Predictability and Greater Strength with Reduced Weight!

THE R. C. MAHON COMPANY • Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON

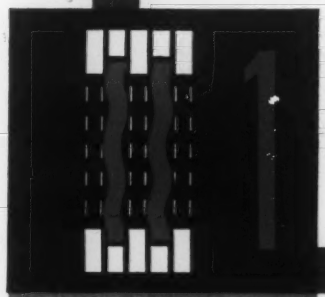
Circle 440 on Page 19

if **BRAKES** are your problem

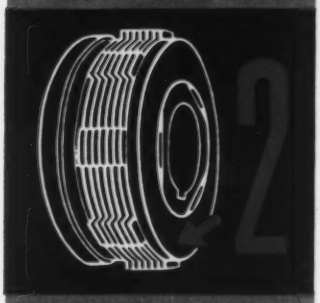
let's talk

Maxitorq

the floating disc clutch that is equally efficient as a **BRAKE**

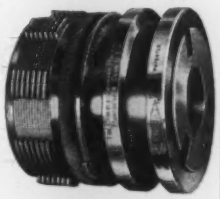


Unique separator springs completely separate floating discs when in neutral, preventing drag or heating.



Locking plates hold discs and separator springs in correct and complete assembly. Easily installed, easily serviced.

Simple manual adjustment by rotating this locked ring. Requires no special tools.



Single

Double

Here is a practical and efficient answer to the majority of brake problems in machine tool and industrial machinery drives, because the service-proved advantages of MAXITORQ Floating Disc design apply equally to the use of these dependable units *either as clutches or brakes.*

These advantages include compact, simple and rugged construction, ideally suited to "designed-in" applications. With patented MAXITORQ separator spring design, engagement and disengagement is always positive and complete, with no drag or heating in neutral. MAXITORQ Brake or Clutch Units are furnished complete, ready to install, with simple manual adjustment—no special tools required.
Can be used either WET or DRY and assure long, trouble-free service. Let our Engineering Department help you solve either BRAKE or CLUTCH problems this proved way.
Send us an outline of your needs. Write Dept. MD-8.

The Carlyle Johnson Machine Co.

MANCHESTER • CONNECTICUT

3CJ3B

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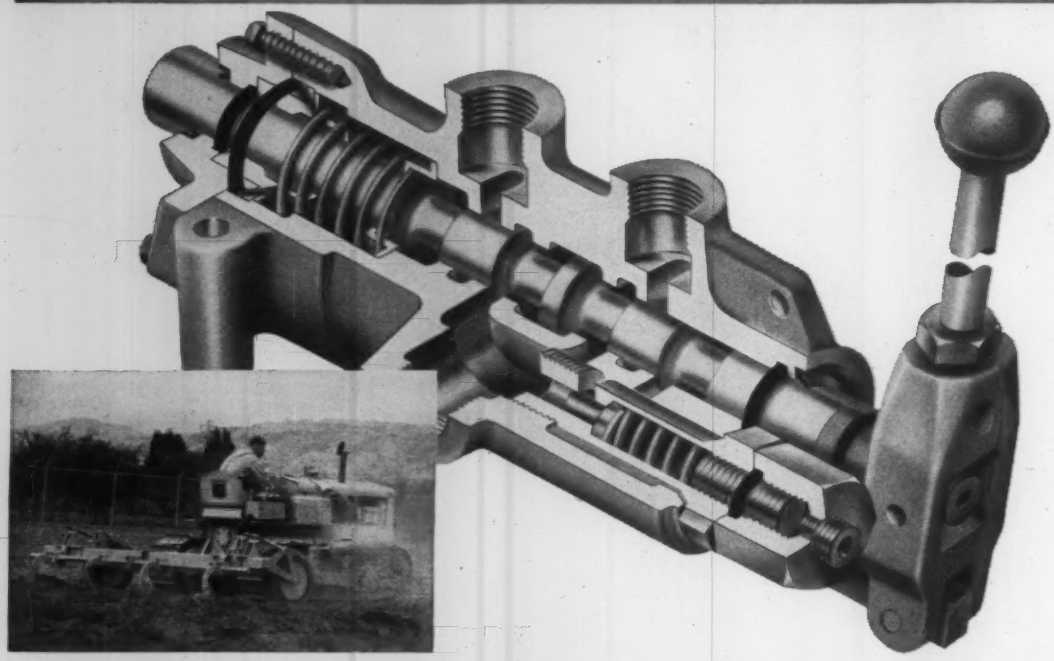
NATIONAL OIL SEAL LOGBOOK



Use of O-rings as moving seal in heavy duty bulldozer control valve

1,500 psi variation without backup rings. Intermittent operation plus long periods of inactivity. Extreme external dust and dirt conditions. Irregular and unpredictable field servicing. Fluid oil temperatures reaching 180°F. Climatic temperature extremes from —30° to +120°F. Life expectancy is required to be that of the tractor.

Above are the rugged operating conditions faced and met by National industrial O-rings in the new Be-Ge Model SU-1200F bulldozer blade control valve. A total of four rings are employed in each unit; two in a moving shaft application and two as static seals.

Be-Ge reports no leakage or ring failure on hundreds of heavy duty applications involving Oliver, Caterpillar, International Harvester and other crawler tractor installations.

National offers a complete line of industrial O-rings, plus many exclusive compounds. Special compounding is also available to meet unusual conditions.

For complete information on National O-Rings, or for skilled O-ring engineering service, call your nearest National Seal engineer. In major cities nationwide. See the Yellow Pages, under "Oil Seals".

Syntech® Oil Seals

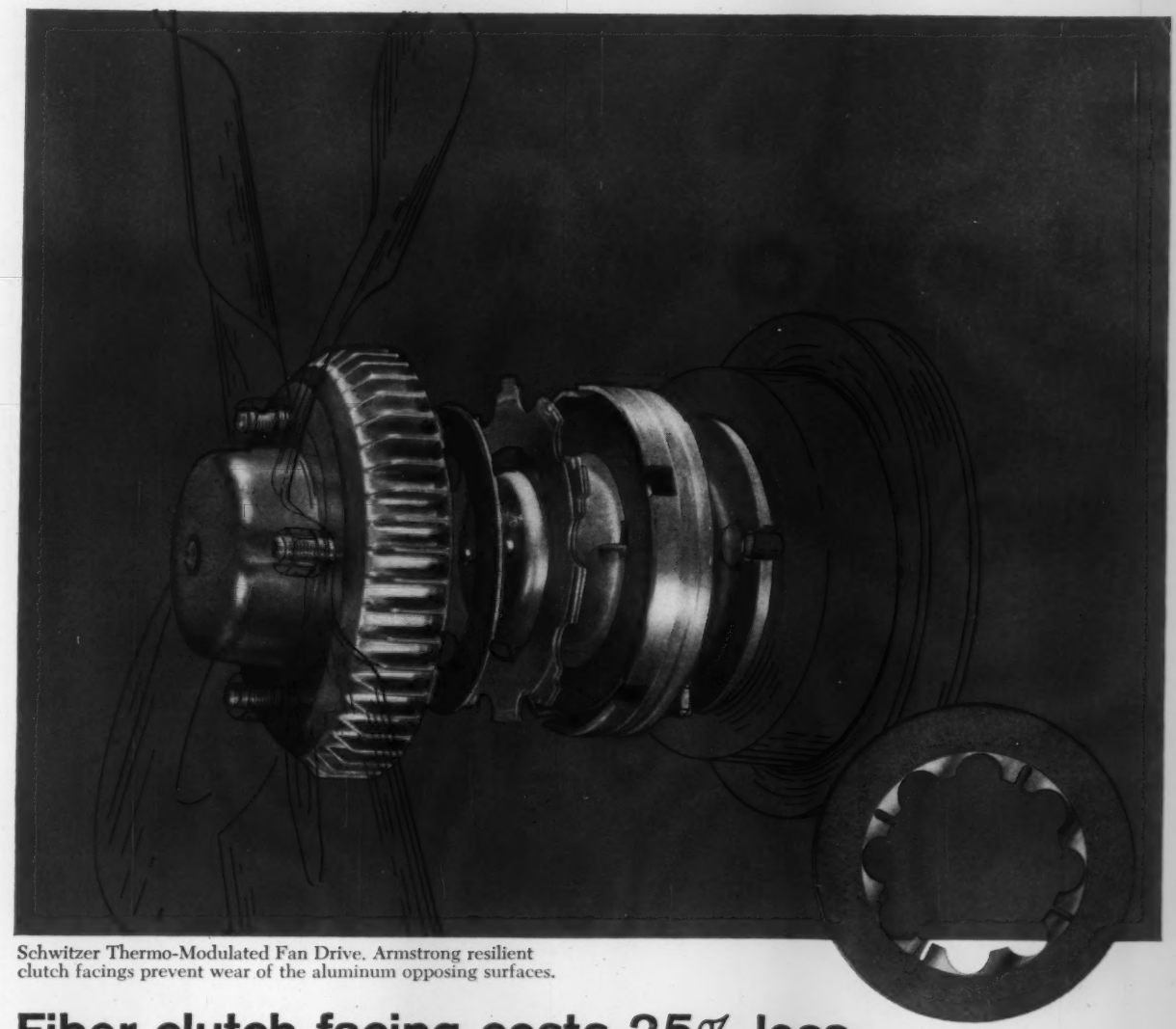
Syntech oil seals, developed by and offered exclusively by National, are widely used synthetic rubber seals for applications where temperatures reach 250°F, speeds reach 3,600 FPM, and total indicator runout is as high as .030. Basic 50,000 series Syntech (illustrated) employs a tough, accurately manufactured steel outer case, precision-tensioned spring and accurately molded and trimmed Syntech sealing lip.

Micro-Torc Oil Seals

Micro-torc oil seals, pioneered by National, are sturdy, dependable leather seals. Special elastomer coating on *surface* of chrome re-tanned leather sealing lip prevents seepage of oil. Yet inner body of sealing lip retains natural porosity to "store" lubricant against accidental periods of starvation. Inherent lubricity of elastomer coating produces a lower torque, longer lasting, economical oil seal. Available in a wide variety of types and sizes.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City and Downey, California

4624



Schwitzer Thermo-Modulated Fan Drive. Armstrong resilient clutch facings prevent wear of the aluminum opposing surfaces.

Fiber clutch facing costs 25% less, avoids wear of aluminum surfaces

A problem often posed for clutch designers is how to prevent opposing surfaces from being worn or scored by the friction material, especially when aluminum or other lightweight metals are used.

Schwitzer Corporation engineers eliminated such wear and also cut friction material costs 25% by adopting Armstrong FM-45, a fiber facing, for the fan-drive unit above.

This temperature modulated fan drive, used on trucks and buses, matches fan speed to engine cooling demands. The friction material must 1) have enough torque capacity to engage positively while immersed in silicone, 2) resist 250° F. temperatures for long periods, and 3) avoid scoring opposing plates.

Of the materials tested for this unit, only FM-45 met the performance requirements and yet would not wear the aluminum—and it cost ¼ less.

Armstrong resilient facings offer high torque capacity, long wear, low cost, smooth engagement, and resistance to pressures of several hundred psi and temperatures over 300° F. If your application requires any combination of these factors, it will pay you to talk it over with your Armstrong man.

SEND FOR INFORMATIVE BOOKLETS

For information on Armstrong's complete line of resilient facings, send for booklet IND-678. If you'd like specific data on fiber materials, ask for booklet IND-953. Armstrong Cork Company, Industrial Division, 7208 Dean Street, Lancaster, Penna.

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

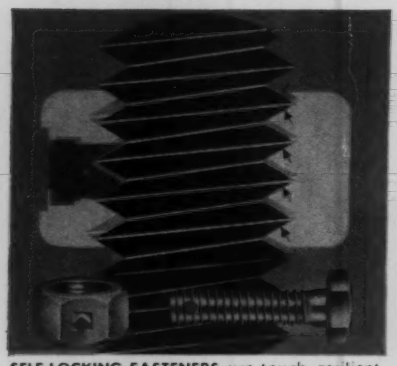
Circle 443 on Page 19

DU PONT

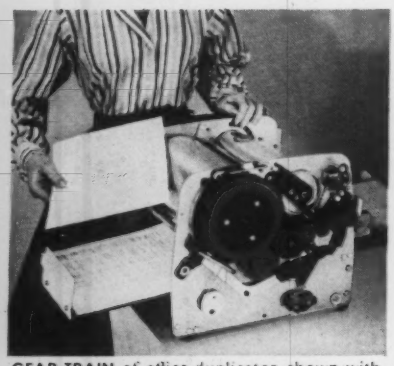
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

PRODUCT
ZYTEL®

Here's how Du Pont ZYTEL® nylon resins

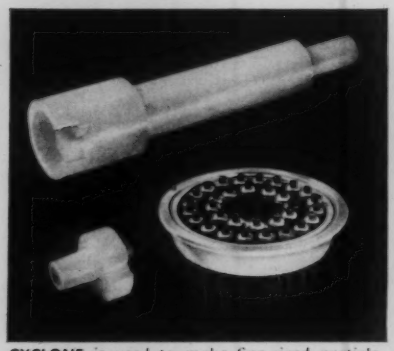


SELF-LOCKING FASTENERS use tough, resilient pellets of ZYTEL to exert powerful lateral thrust. Strong metal-to-metal lock between opposite mating threads results (see arrows). (By Nylok Corporation, Paramus, New Jersey.)

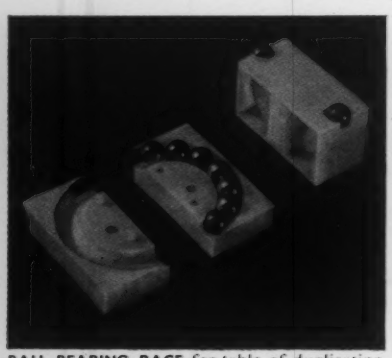


GEAR TRAIN of office duplicator, shown with side cases removed, is made of Du Pont ZYTEL nylon resin. Parts operate quietly . . . are strong and durable. (Molded by Hauser Products, Inc., for Heyer Corp. — both of Chicago, Ill.)

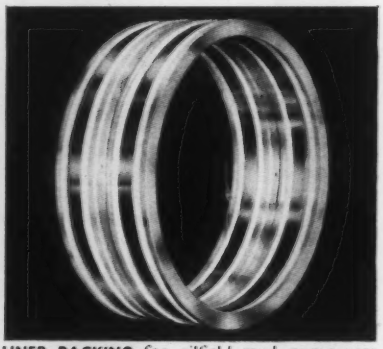
CHECK VALVE won award for best use of materials in design. Parts were reduced from 10 to 6 and their cost cut by 68%. (Molded by Hamilton Plastic Molding Company for OPW Corp.—both of Cincinnati, Ohio.)



CYCLONE is used to make fine-sized particle separations. The abrasion resistance and chemical resistance of ZYTEL are vital in this application. (Molded by Dickmont Plastics Corp. for Dorr-Oliver Inc.—both of Stamford, Conn.)

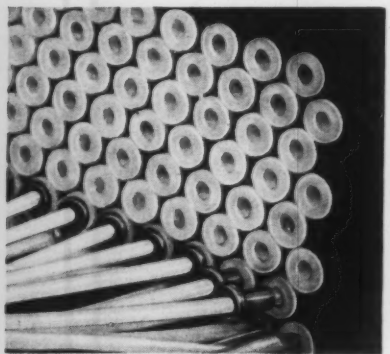


BALL BEARING RACE for table of duplicating miller provides cost savings, smoother table action, high resistance to abrasion. (Molded by Dickmont Plastics Corp., Stamford, Conn., for Regent Machine Co., Bridgeport, Conn.)

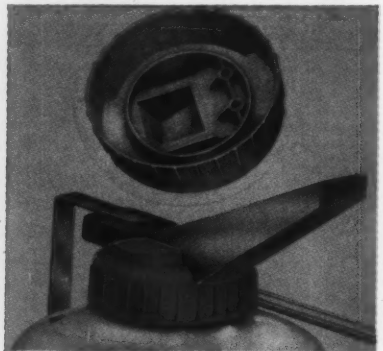


LINER PACKING for oilfield mud pump uses big, resilient, chevron-type rings of Du Pont ZYTEL nylon resin to achieve a rugged, close-fitting assembly. (By Blackwell Plastic Molding Co. for Mission Mfg. Co.—both of Houston, Texas.)

RESPIRATOR INSERT of Du Pont ZYTEL nylon resin is easily molded to exacting standards of strength, providing toughness with adequate stiffness. (Made by Wilson Products Division of Electric Storage Battery Co., Reading, Pa.)



COMPRESSION FITTINGS of ZYTEL quickly connect tubing of the same material to the ink supply control board of a newspaper printing machine. (Presslok® fittings by Nylon Molding Corp., Garwood, N. J.; used by Wood Newspaper Machinery Corp., Plainfield, N. J.)

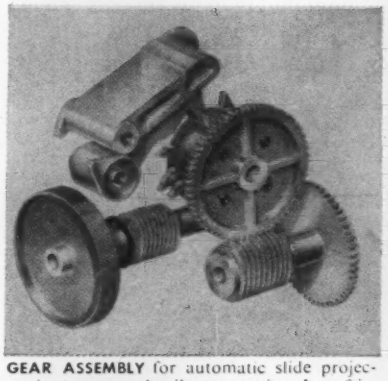


CAP for vaporizer is molded of Du Pont ZYTEL nylon resin in bright pastels. The intricate part has high strength . . . excellent heat resistance. (Vaporizer by Kaz, Inc., New York, N. Y.; cap by Pyro Plastics Corp., Union, N. J.)

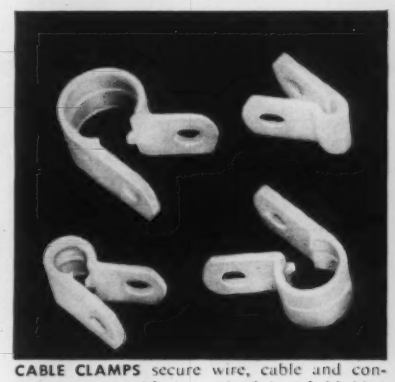
ENGINEERING NEWS

NYLON RESINS

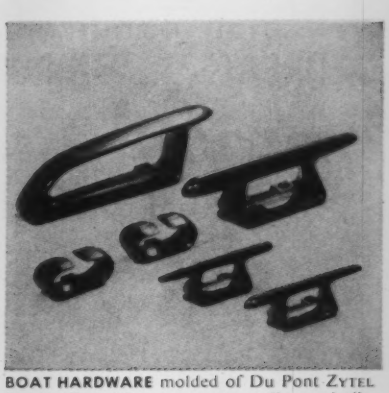
improved 14 recent product designs...



GEAR ASSEMBLY for automatic slide projector insures smooth, silent operation. Low friction of ZYTEL reduces lubrication needs. (Made by Wollensak Optical Co., Chicago, Ill.; parts molded by Thorgren Tool and Die Co., Valparaiso, Ind.)

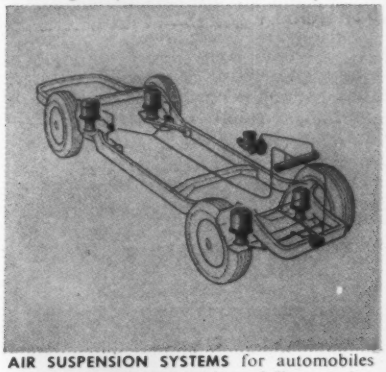


CABLE CLAMPS secure wire, cable and conduit to structural framework of aircraft. Molded of lightweight, resilient ZYTEL, they form a perfect circle with tongue and groove giving a positive, vibration-proof grip. (Molded by Nylon Molding Corp., Garwood, New Jersey.)



BOAT HARDWARE molded of Du Pont ZYTEL is not affected by sea water, gasoline and oils. Colors complement the finish of the boat . . . high strength of ZYTEL assures safety. (Made by Danielson Manufacturing Company, Danielson, Connecticut.)

PIPE CLAMPS grip fuel lines in jet aircraft . . . withstand strong vibration. Light weight of ZYTEL nylon resin (sp. gr. 1.14) . . . plus exceptional toughness and tensile strength . . . makes it especially useful in airplanes. (By Nylon Molding Corp., Garwood, New Jersey.)



AIR SUSPENSION SYSTEMS for automobiles depend on extruded tubing of ZYTEL nylon resin. Tubing needs no pre-bending, is tough, resistant to abrasion. It can be used with standard fittings and operates over a wide temperature range (-40 to 250°F.).

Outstanding design properties of ZYTEL® nylon resins feature high strength...ease of fabrication

The dramatic improvements in design which started when strong, high-melting thermoplastics such as ZYTEL became available continues to this day, as these recent products show.

Important production advantages are one reason. ZYTEL nylon resins have a high, relatively sharp melting point. Because of this sharp melting point, ZYTEL sets up fast and gives shorter molding cycles. Multicavity dies in an injection-molding process speed up production still more. Extremely complicated and precise shapes are possible. Surfaces can be formed so smoothly and accurately that the need for machine finishing is usually eliminated.

Structurally, parts of ZYTEL have a great deal to offer. ZYTEL nylon resins have the highest strength-to-weight ratio of any plastic. Parts are extremely resistant to abrasion and impact. Owing to its resilience and low surface friction, ZYTEL is commonly used to make gears and bearings. A series of formulations are available to meet a variety of end-use requirements.

SEND FOR INFORMATION

For information showing you how to design with ZYTEL nylon resins, just mail the coupon.

E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Department, Room 228, Du Pont Building
Wilmington 98, Delaware.

Please send me more information on Du Pont ZYTEL nylon resins. I am interested in evaluating this material for:

Name _____ *Position* _____

Company _____

Street _____

City _____ *State* _____

Type of Business _____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

Circle 444 on Page 19

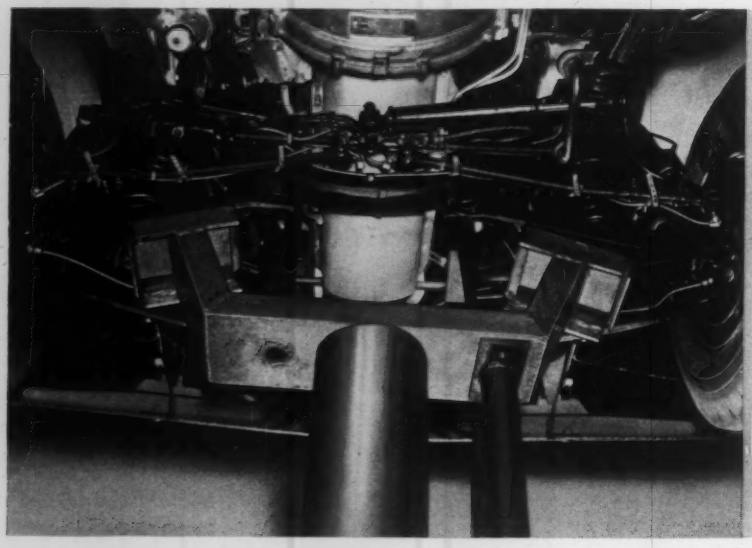
lubri-facts from Lincoln

No. 104 of a series of case histories on the vital role of lubricant application systems in engineering design.

DESIGN ENGINEERS PROVIDE PUSH-BUTTON LUBRICATION, CREATE NEW PRODUCT SALES ADVANTAGES THROUGH

Lincoln Power Lubrication Systems

- Assure positive pressure lubrication to all bearings, simultaneously
- Increase machine efficiency in the plant, on the road, in the field
- Pay for themselves in customer savings



Case History:

LINCOLN, MERCURY and EDSEL DIVISIONS, THE FORD MOTOR CO.

Uniform, maximum efficiency of performance is assured for Lincoln, Mercury and the new Edsel cars with Multi-Luber* Automatic Power Lubrication Systems. Provide quieter, smoother car operation, easier steering, perfect bearing protection.

The Lincoln, Mercury and Edsel Divisions of Ford Motor Company are among the many progressive manufacturers who are opening up new sales opportunities . . . by providing automatic lubrication for these outstanding motor cars through low-cost Lincoln Multi-Luber Power Lubrication Systems. This tested method of lubricant application permits simultaneous lubrication of all bearings in seconds . . . on automobiles, or on any equipment or machinery having multiple bearing points. Assures proper, frequent lubrication . . . flushes bearings as it lubricates . . . extends bearing life and eliminates costly lubrication downtime. Easy to use . . . simple to install . . . precision-built to last.

Add more sales features to your product or original equipment with cost-cutting Lincoln Power Lubrication Systems. Air, vacuum or manually operated. Write today for full details. Ask for Engineering Catalog No. 811.

Most trustworthy name in modern lubrication equipment for industrial, automotive, agricultural, construction and other uses.

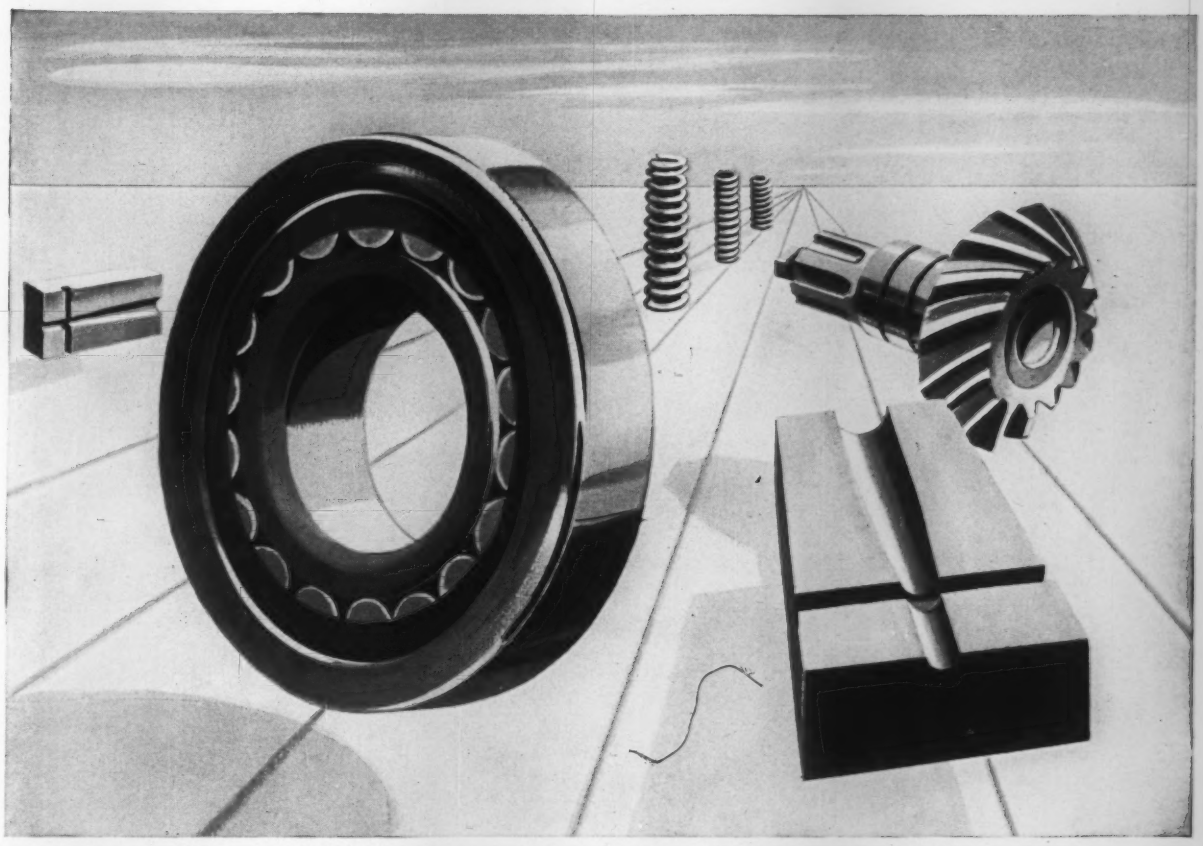
*Trade Name Registered

Lincoln

LINCOLN ENGINEERING COMPANY

Division of The McNeil Machine & Engineering Co.

5736 Natural Bridge Avenue • St. Louis 20, Missouri



Vacuum-melted alloys make parts stronger . . . give them operational dependability and longer life. Can a General Electric vacuum-melted alloy solve a design problem for you?

General Electric vacuum-melted alloys open vast new areas for mechanical design

G-E alloys have remarkably improved mechanical properties . . . are consistently pure and easier to fabricate

Notable advances in the design of aircraft propulsive systems have already been made possible by the development of vacuum-melted metals by the General Electric Company. And these better alloys can now make radical designs feasible in other mechanical fields.

Melting metals in a near-perfect vacuum makes them cleaner, essentially free from inclusions, impurities, gases, and oxides. Entirely new metals can be alloyed that could not even be made by air melting methods.

These superior properties of G-E vacuum-melted alloys include improved ductility, making otherwise unworkable metals easy to forge, weld or form; more uniform properties, giving operational reliability to machine components; and superior fatigue properties to give springs and diaphragms longer service life and consistent performance at high temperatures and stresses. And vacuum melting permits improvement in corrosion and oxidation resistant alloys because larger quantities of reactive metals can be used than is possible with air melting techniques.

General Electric vacuum-melted alloys can now be designed and produced to exacting specifications with consistently predictable properties and dependable life. You can order them in sheets, bars, billets and forgings.

Our metallurgical engineers are ready to help you select – or design – vacuum-melted alloys to meet your specifications. For more information – or the assistance of a G-E engineer – call or write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Street, Detroit 32, Michigan.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 446 on Page 19

Engineered by Tinnerman...

It's a fastener...It's a friction-lock... It's a Tinnerman **SPEED NUT**® doing double-duty

Turn this Westinghouse Mobilaire® Fan to any angle... and it *stays* angled. The Tinnerman SPEED NUT Brand Fastener that holds the fan trunnions tight to the housing also supplies live spring-tension to keep the fan positioned at any angle you choose.

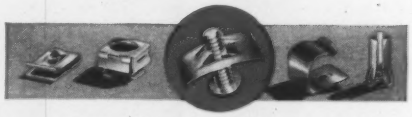
These SPEED NUT fasteners, developed by joint efforts of Tinnerman and Westinghouse designers, eliminate special adjusting thumb-screws. Only 2 SPEED NUT parts serve the purpose of several stampings and ordinary fasteners. Material and assembly costs are lower than with ordinary fastening methods. And the consumer gets a better fan that's easier to adjust.

Chances are that Tinnerman designers can develop SPEED NUT parts for your product to cut costs, speed production, improve that product.

Call your local SPEED NUT representative now ... if he's not in your Yellow Pages Directory under "Fasteners", write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®



FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

THE MOMENTOUS DETAILS OF DESIGN

with MADISON-KIPP Zinc and Aluminum Die Castings

Renowned furniture craftsmen of the ages gave modern designers a most important clue to success—close attention to details.

Imagine inelegant legs on this *All Steel Desk. The effect would be jarring. The Kipp die cast desk legs blend with the over-all design and as a detail are of momentous importance.

Product designers know what they want in last word engineering features. Attentive mechanics at Madison-Kipp have been helpful to highly placed designers and engineers for over a quarter century in applying die castings effectively and economically.

They invite you to clip this ad as a reminder to contact them when you have die casting requirements.

*All-Steel Equipment, Inc., Aurora, Illinois

kipp

MADISON-KIPP CORPORATION
210 Waubesa Street Madison 10, Wisconsin

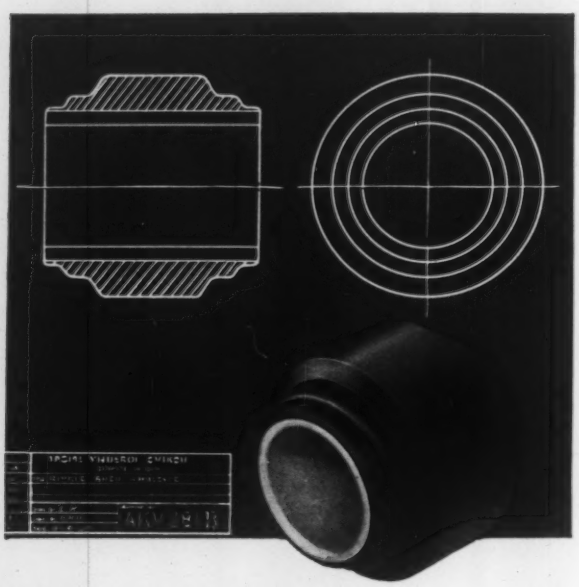
Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Circle 448 on Page 19

Engineering With Rubber For Improved Performance

These examples show how Dayton molded product engineers are working with mechanical designers to help them achieve new product performance standards. Pre-engineered in combinations of tension, compression and shear for exact deflection requirements, these quality Dayton molded products replace metal-to-metal parts . . . eliminating grease fittings, reducing metal wear and maintenance problems, simplifying assembly, and giving long service.

Rubber tire in this flexible coupling is held by flanges and clamp rings . . . cushions shock loads, reduces torsional vibration, and accommodates angular and parallel misalignment and end float. A transverse split is molded into the tire, permitting replacement without disturbing the shafts. No lubrication is required.



Rubber-to-metal bushing, bonded for life to its inner metal by the quality Dayton process, accommodates torsional and angular motion at the radius rod ends. It provides a flexible pivot joint, eliminating metal wear and lubrication, absorbing shock, noise and vibration. With extreme radial stiffness and maximum torsional flexibility, this bushing is easy to install and can be positioned exactly.

Engineered rubber is the answer to your needs in vibration, noise and shock control . . . inherent misalignment of mechanical elements . . . simplifying assembly problems . . . and reducing maintenance costs. Dayton has design and production facilities to give you complete service from blueprint to finished product. Consult our molded product specialists.

THE DAYTON RUBBER CO., THREE RIVERS, MICHIGAN
MOLDED PRODUCTS SALES DIVISION

I have a design requirement and would like to talk more about it with one of your sales engineers.

*Name*_____

*Company*_____

*Address*_____

*City & State*_____

RUBBER · RUBBER-TO-METAL · RUBBER-TO-FABRIC

Dayton Rubber

MOLDED PRODUCTS SALES DIV., Three Rivers, Mich.

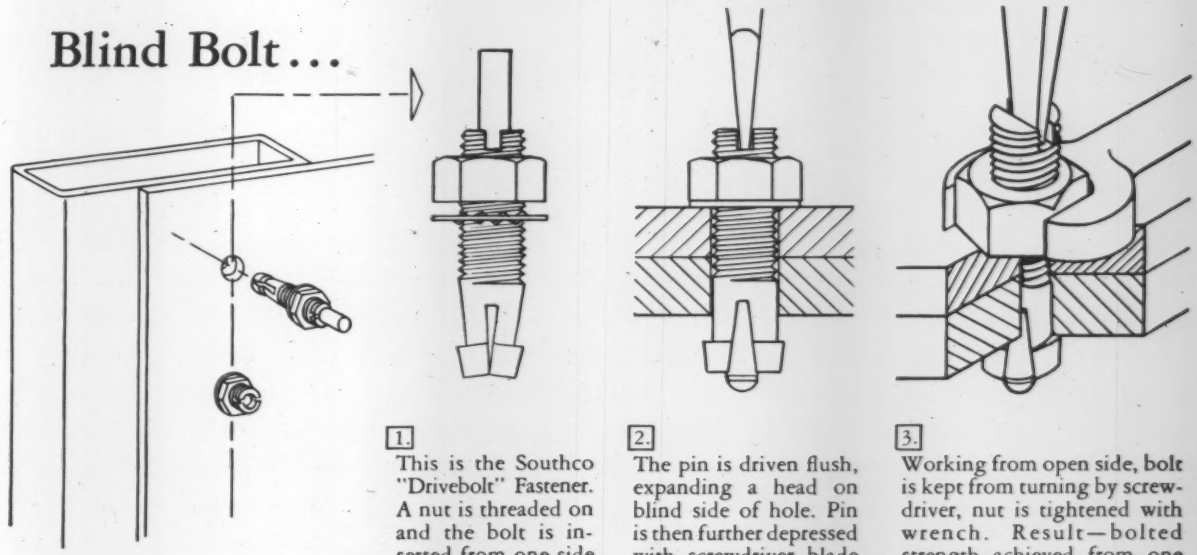
BRANCH SALES OFFICES IN: Dayton, Ohio · Detroit, Michigan Hillside, New Jersey · Atlanta, Georgia · Chicago, Illinois Dallas, Texas · Los Angeles, California

Circle 449 on Page 19

Simplified Bolting and Riveting in Blind Applications

For fastener applications accessible only from one side of the work, you can now bolt or rivet without special tools . . .

Blind Bolt . . .

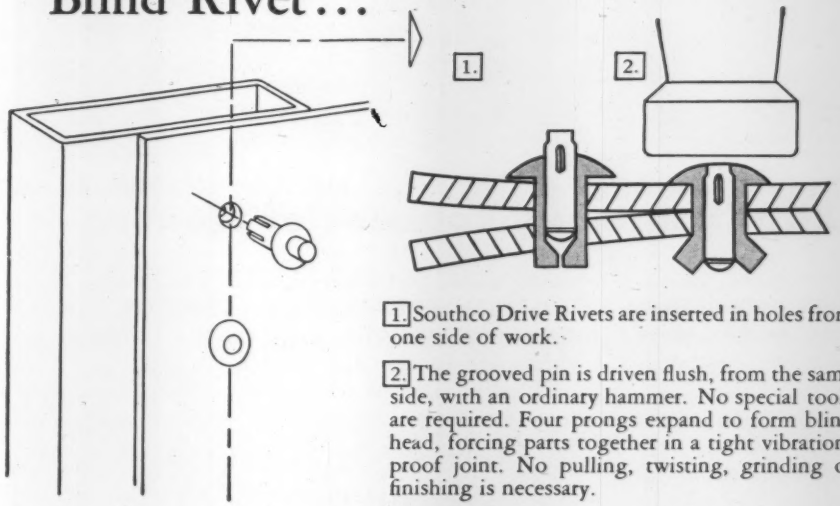


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet . . .



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

FREE!

Fastener Handbook

Send for your free copy of Fastener Handbook No. 8, just released. Gives complete engineering data on these and many other special fasteners. Forty - eight pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

©1956

Circle 450 on Page 19

Will Help Control Enormous Volumes of Steam

This odd-shaped forging is as husky and rugged as it looks. It's an interceptor valve body, made of electric-furnace alloy steel, and it's going to be pitted against the forces of steam. The finished valve will be one of the flow-control units in a big turbine system.

Starting with a corrugated ingot, Bethlehem forged and machined the part to rigid specifications. Here you see it just about ready for shipment to the customer. Shipping weight, approximately 7800 lb.

This is a good example of the medium-sized forgings that Bethlehem is equipped to make. But if you need smaller pieces, Bethlehem can easily furnish them (drop forgings, for example, weighing as little as a pound). And our shops also make the largest forgings ever required—some weighing more than 100 tons.

Call us when we can be of service to you or members of your staff. Our engineers will gladly cooperate, from the planning stage to the finished product.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

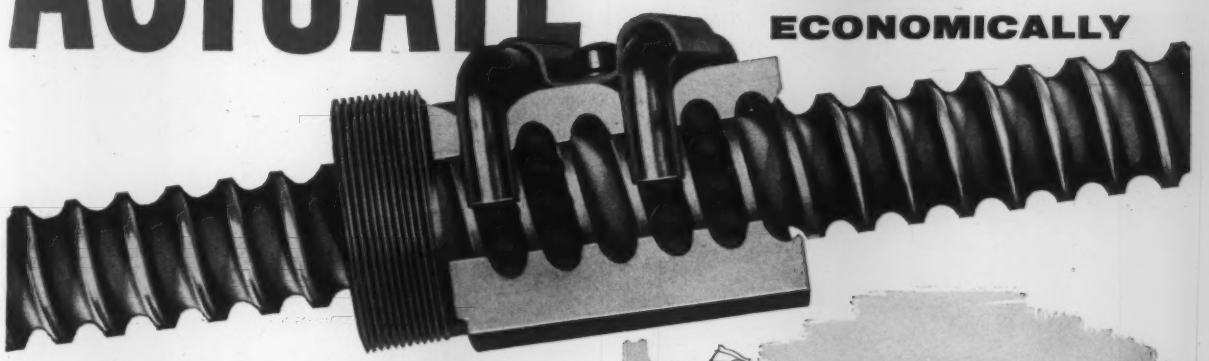
BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 451 on Page 19

ACTUATE

MORE QUICKLY . . .
EFFICIENTLY . . .
ECONOMICALLY



ROLLED THREAD
SAGINAW b/b SCREWS
Give Volume Products New Production and Sales Advantages

Because Saginaw employs an important anti-friction principle—steel balls recirculating in closed-circuit raceways—b/b Screws provide efficiencies of over 90%—perform up to *5 times* better than acme screws. Saginaw b/b Screws require far less torque—save up to 85% on operating power or manual effort. They are smaller and lighter than comparable units—permit smaller motors and gear boxes; often eliminate clumsy auxiliary parts. May be used with flange, trunnion, worm wheel or torque tube adaptors. Smooth, almost frictionless operation assures long, trouble-free performance, even in extreme temperatures and with lack of lubrication.

"OFF-THE-SHELF" STOCK REDUCES COST

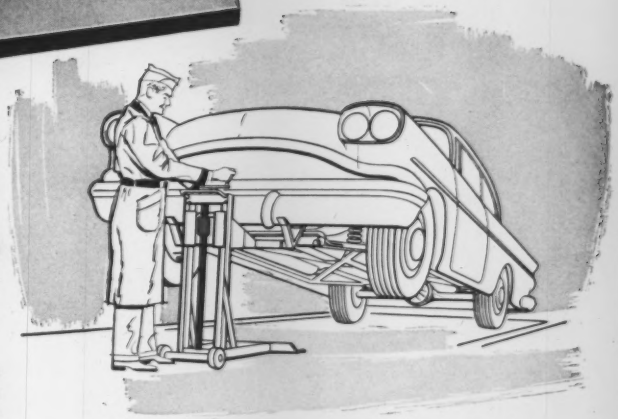
Saginaw b/b Screws are the only kind stocked in seven commercial rolled thread sizes, in 6-inch increments of length (up to 4 ft. for .375" BCD, 8 ft. for .631" BCD, and 11 ft. for all larger sizes.) Ball Circle Diameters are as follows:

.375" .631" 1.000" 1.171" 1.500" 2.250" 3.000"

MANY TYPICAL APPLICATIONS

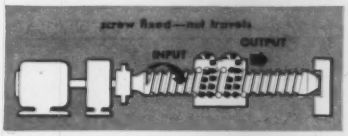
Saginaw b/b Screw standard assemblies have been successfully applied to such products as bumper jacks, automatic garage doors, automobile seat adjusters and window lifts, beauty parlor chairs, hospital beds, and circuit breakers. They are also being used in heavy industrial equipment like die table positioners, drill presses, lift trucks and welding machines.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION



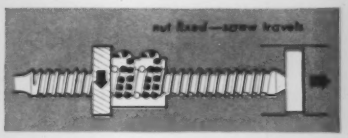
With a Saginaw b/b Rolled Thread Screw in the jack, just a spin of the handle raises a heavy car easily . . . smoothly . . . safely.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque.

SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with new efficiency.



LET SAGINAW'S EXPERIENCED ENGINEERS HELP SOLVE YOUR SPECIAL APPLICATION PROBLEMS . JUST WRITE OR PHONE US—NO OBLIGATION

Saginaw ball bearing Screw

SAGINAW STEERING GEAR DIVISION • GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

Circle 452 on Page 19

Timken-Detroit® Drives Put Power To Work

This self-propelled Allis-Chalmers combine, equipped with a Timken-Detroit driving assembly, harvests mountains of wheat with almost effortless ease. It is another outstanding example of the successful co-operation between leading builders of self-propelled equipment and Rockwell-Standard Corporation.

The driving assembly used here came from the complete line of Timken-Detroit axles. By "customizing" a standard assembly to meet Allis-Chalmers' needs and specifications, our engineers were able to provide the exact driving unit required. Result: the manufacturer was able to avoid the high cost of a new, "one-of-a-kind" component . . . get into production faster . . . and eliminate the expense of additional facilities.

Once again, Rockwell-Standard proved it is more economical for vehicle manufacturers to draw on specialists for their special needs. If you have a problem involving driving assemblies, call in Rockwell-Standard axle engineers. It costs you nothing, and it will prove very helpful.

Plants at: Detroit, Michigan
Oshkosh, Wisconsin • Kenton and Newark, Ohio
New Castle, Pa.

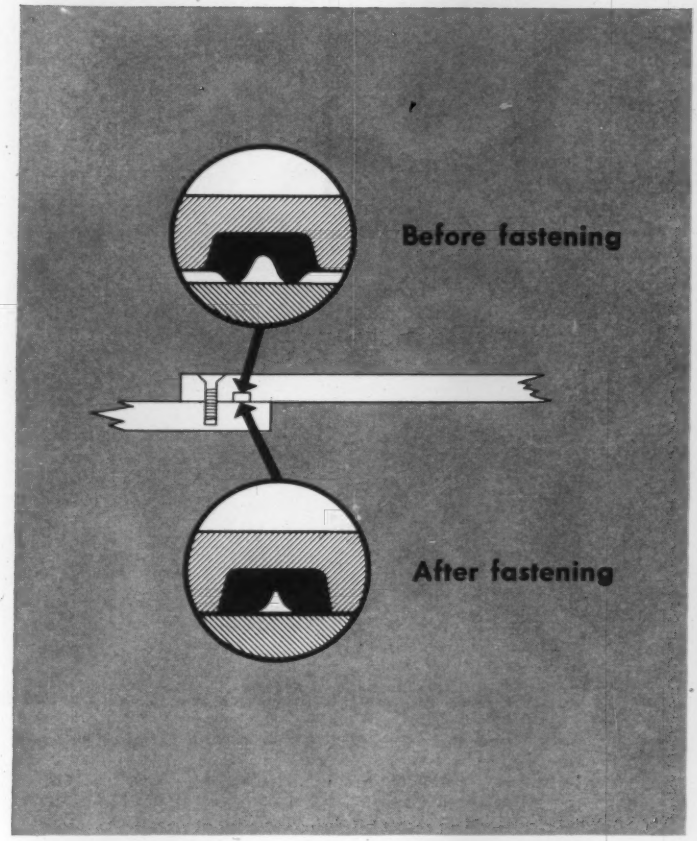
TIMKEN Detroit AXLES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN
An Accepted Standard
TRADE MARK REGISTERED

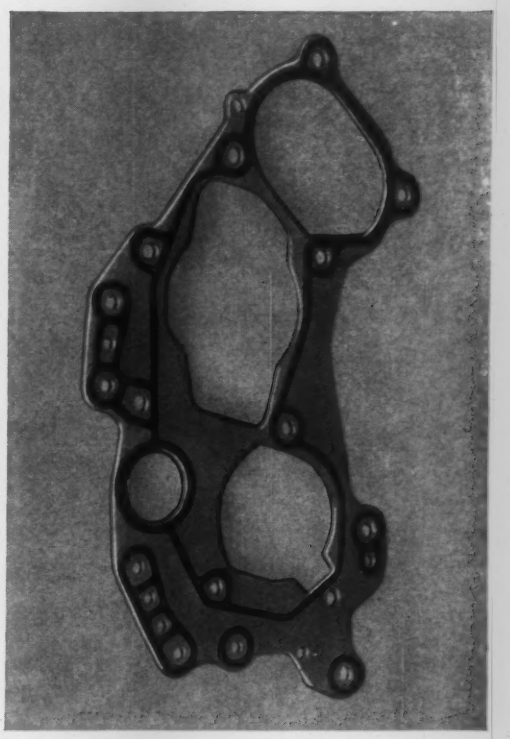
©1958, R-S Corp.

Products of **ROCKWELL-STANDARD** Corporation

Another new development using

B.F.Goodrich Chemical *raw materials*





Diagrams show functioning of Gask-O-Seal, manufactured by Parker Seal Co., a Division of Parker-Hannifin Corporation, Culver City, Calif. Photo shows flexibility of application to a wide variety of gasketing problems. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber materials.

uses glands of Hycar

NEW GASKET IDEA PROVIDES SAFE, SURE STATIC SEALING

ZERO-LEAKAGE is a prime requirement when operations call for handling hot oil or chemicals. This new type gasket provides perfect sealing economically with controlled confinement of a gland seal made from Hycar nitrile rubber.

Because they are made of Hycar, these gland seals will not creep under stress. They also resist oxidation, hot oil and many other solvents. Yet their memory of shape is just right to make them resist deformation, provide a perfect tight seal.

Hycar may be the material that can add new advantages to your product, or suggest new applications. For information, write Dept. KK-4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
Reg. U.S. Pat. Off.
American Rubber

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

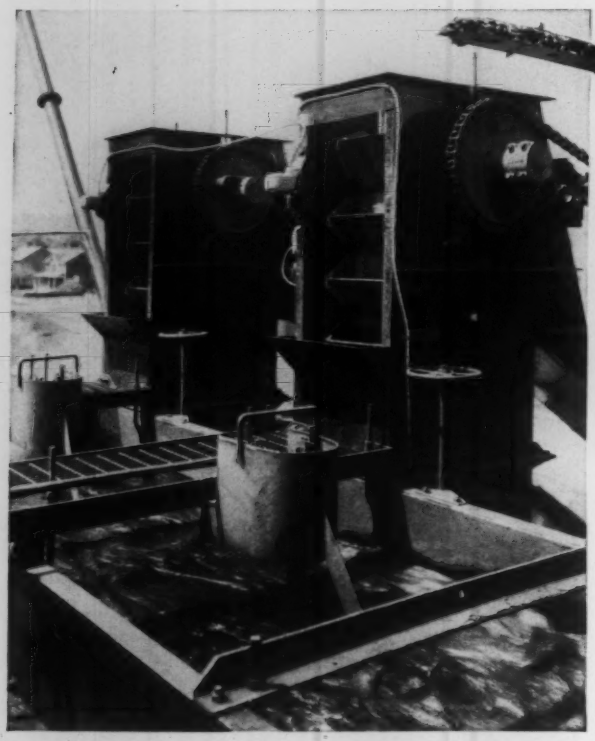
GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • Harmon colors

Circle 454 on Page 19

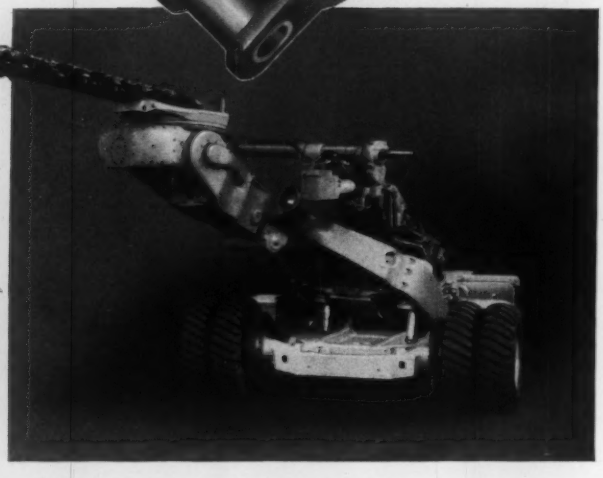
JEFFREY STR* CHAIN

has the reserve strength necessary for hard work and sudden overloads

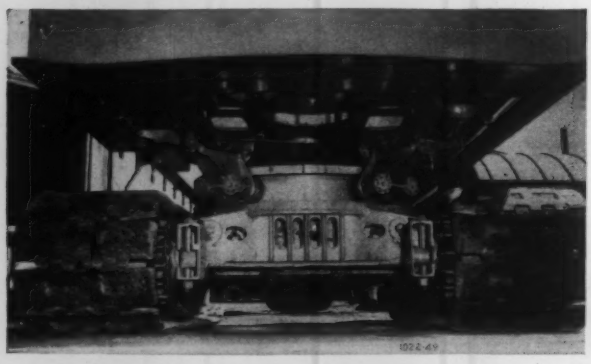
*Steel Thimble Roller Chain



Jeffrey STR Chain on bucket elevator drive of cleaning jig.



Jeffrey STR Chain on traction wheels of large cutter.



Jeffrey STR Chain on crawler drive of power shovel.

YOU SEE MORE and more Jeffrey STR Chain every day. Jeffrey's own high-quality equipment uses Jeffrey STR for dozens of power transmission and conveying applications. Other manufacturers incorporate Jeffrey STR as original equipment on machines they make. And operators everywhere replace chain drives of whatever make with Jeffrey STR.

With Jeffrey STR you get a balanced chain design with maximum strength and minimum weight. Moreover you get the reserve strength so necessary for the hard work and sudden overloads common under full-scale operations.

For dependable, long-life chain for power transmission, conveying and elevating service, see your nearby Jeffrey distributor or district office, or write to The Jeffrey Manufacturing Company, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT • TRANSMISSION MACHINERY • CONTRACT MANUFACTURING

Circle 455 on Page 19

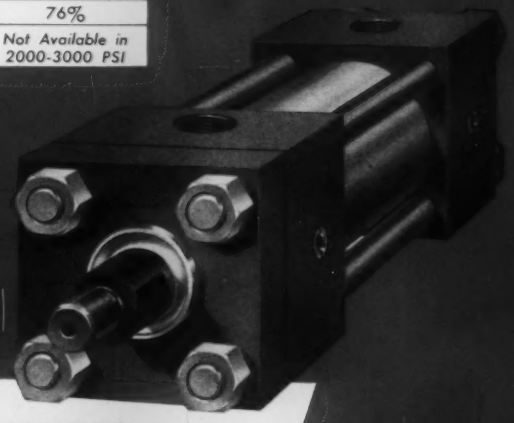
Save 27% or more in cost...

NEW Miller "JOB RATED" HYDRAULIC CYLINDER LINE

JOB RATED, MODEL " J "

BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.



SEAL FAILURE MEANS CYLINDER FAILURE!

1. *No seal made of synthetic rubber is compatible with even 50% of available, commercial, petroleum base hydraulic fluids.*

MILLER Uses All Teflon* Seals to Eliminate External Oil Leakage because Teflon is impervious to all known hydraulic fluids, even fire-resistant types.

TEFLON SHEF SEAL At Tubing Ends

No blind assembly. Is
Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON Seals On Piston Rod And Bushing

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON Seals On Ball Check And Adjusting Screw

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

MILLER Uses Resin-Impregnated Leather Piston Cup Seals because they are compatible with petroleum base fluids and some fire-resistant types. Teflon cups available at small extra cost.

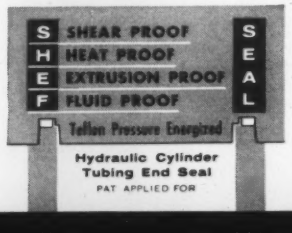
2. *Nicked or scored piston rods cause seal failure*

MILLER Uses Case-Hardened Chrome-Plated Piston Rods because they prevent nicks, scoring and rust.

Write for new bulletin giving complete details plus valuable data on column strength, cylinder forces, pipe sizes, safety factors, acceleration, air-oil devices, and other useful information.

NOW! . . . You can save MORE with quality Miller "Job-Rated" Cylinders than with cut-price, lesser quality hydraulic cylinders. And the "Job-Rated" Cylinders are also available under the same immediate shipment program as the Power-Packed Line (2 hours if necessary—3 days normal).

* Du Pont trademark for tetrafluoroethylene resin which withstands temperatures from −100° F. to +500° F. and all hydraulic fluids.



OTHER MILLER QUALITY FEATURES

- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Precision Honed Barrels

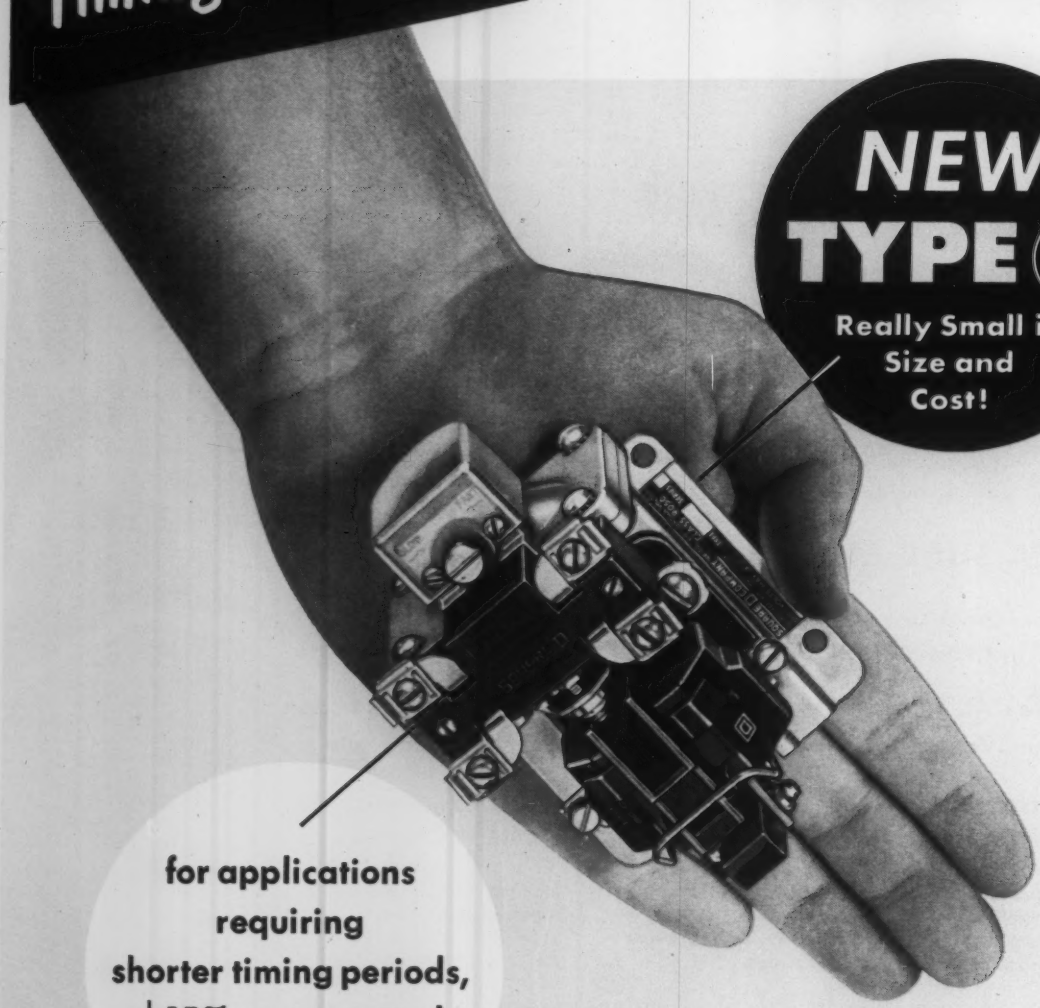
Circle 456 on Page 19

MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION
2006 N. Hawthorne Ave. Melrose Park, Ill.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

What's Your Timing Problem?

ONE OF THESE WILL DO



NEW TYPE A

Really Small in Size and Cost!

for applications requiring shorter timing periods, ±15% accuracy and no interlocks

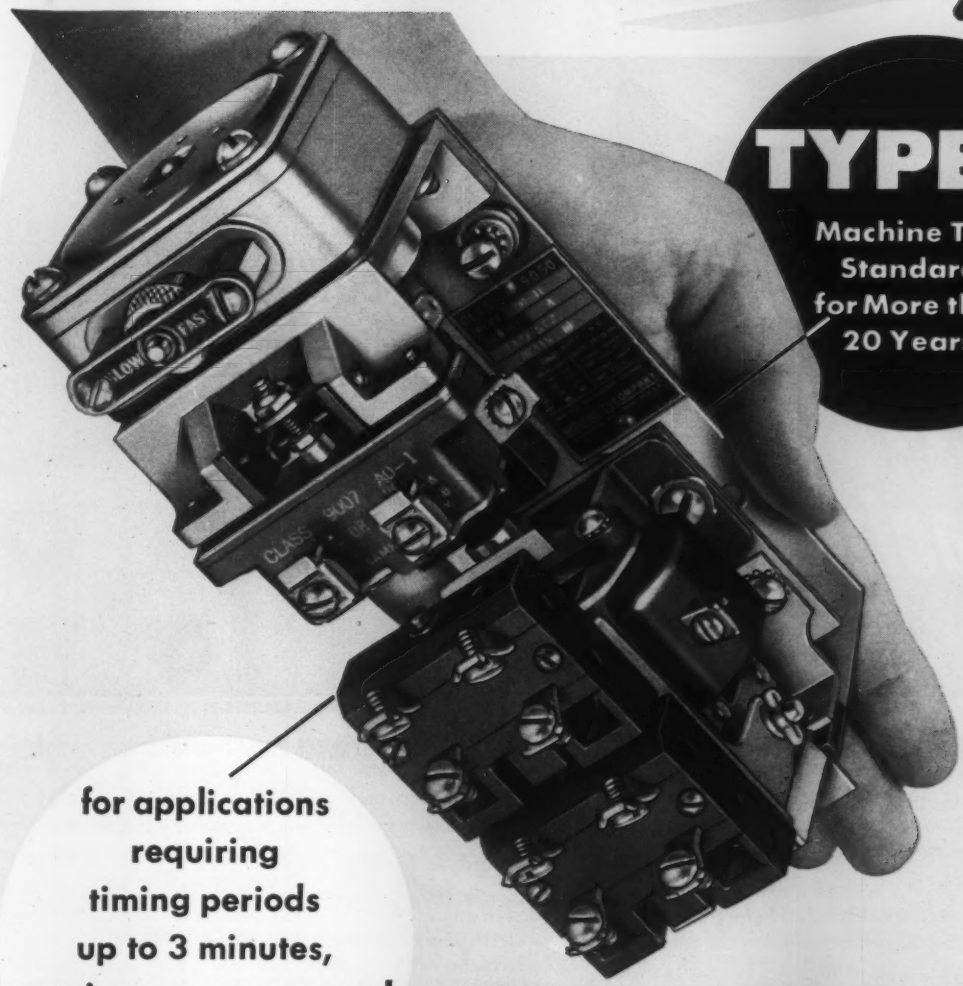
Write for Timer Bulletin 9050

Address Square D Company,
4041 North Richards Street, Milwaukee 12, Wisconsin

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SQUARE D TIMERS YOUR JOB ... *Exactly!*



TYPE B

Machine Tool Standard for More than 20 Years!

for applications requiring timing periods up to 3 minutes, maximum accuracy and 1 or 2 instantaneous interlocks

COMPARISON	TYPE A	TYPE B
Timing Period	.2 to 1 min.	.2 to 3 min.
Accuracy	±15%	±10%
Interlocks	None	Max. 2 Double Circuit
Panel Space	2⅜" x 4"	2½" x 7⅜"
Convertible Delay-On • Delay-Off	Yes	Yes
Maximum Voltage, AC-DC	600 V. AC only	600 V. AC • 250 V. DC

Everybody's Ahead with Square D!

Circle 457 on Page 19

Why aircraft designers specify Formsprag Over-Running Clutches for maximum torque — minimum weight

More and more, in modern aircraft manufacture, design engineers find themselves facing this challenging dilemma; how to pack more and more performance into less and less space.

One obvious answer: select smaller, lighter components capable of bettering bigger component's output. This is why so many designers are contacting Formsprag when they have power transmission applications.

They have discovered these vital advantages built into each truly modern Formsprag clutch: more torque capacity with less weight providing greater payload than any other over-running clutch . . . high efficiency . . . internal design simplicity . . . no measurable backlash.

Perhaps you too have a project on which the performance vs. size problem could be solved by Formsprag design engineers. Formsprag over-running clutches are widely used as component parts of gas turbine starters, alternator drives, rudder and landing gear actuators, hoists, and helicopter transmissions. For engineering design assistance simply write Formsprag Company. Ask, too, for the new paper titled "Design Considerations for High Speed Over-Running Clutches".

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications.

FORMSPRAG COMPANY

IN CANADA: RENOLD CHAINS CANADA LIMITED

IN UNITED KINGDOM: RENOLD CHAINS LIMITED

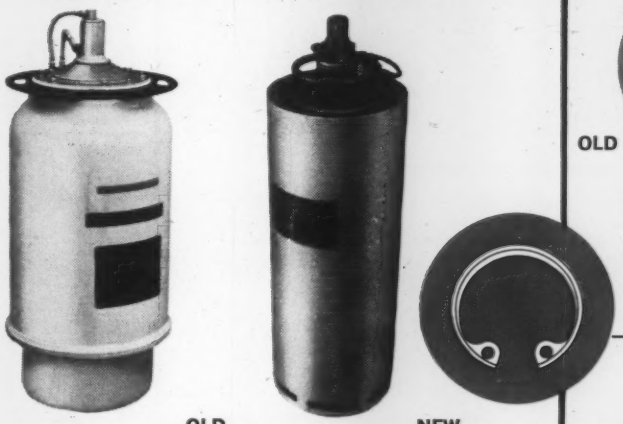
23603 HOOVER ROAD, WARREN (DETROIT), MICH.

World's largest exclusive manufacturer of over-running clutches. Distributors in principal cities. A9-5C

2 Giant Waldes Truarc Beveled Rings Cut Costs $500, Save 76½ Hours Machining-Assembly Time on X-Ray Unit

TRIPLETT & BARTON TRI-IND-X PORTABLE X-RAY UNIT

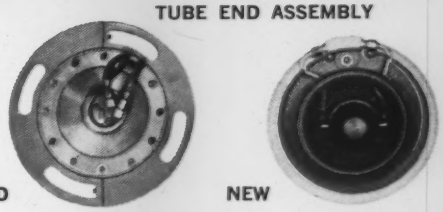
OLD MODEL NEW MODEL



	OLD SPECIFICATIONS	NEW SPECIFICATIONS
Weight	107 lbs.	65 lbs.
Diameter	15 inches	11 inches
Machining and Assembly Time	78 hours	1½ hours
Service Time	4½ hours	5 minutes
Parts	27 bolts	2 Truarc Rings

Prior to adoption in their new bantam-weight TRI-IND-X, Triplett & Barton, Inc., Burbank, Calif., subjected Waldes Truarc Retaining Rings to severe tests and rigid inspections. Although the TRI-IND-X operates at a normal pressure of 50 psi, Truarc Rings were subjected to pressure tests in excess of 500 psi, proving their high performance.

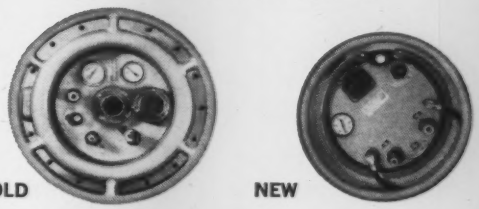
TUBE END ASSEMBLY



OLD NEW

ONE 10" BEVELED RING REPLACES 12 BOLTS—Machining and assembly time formerly required 78 hours . . . now reduced to 1½ hours! Service operations for dismantling or tube change formerly required 4½ hours . . . now reduced to 5 minutes! In addition to savings on materials, costs have been reduced approximately $500 per unit.

END BELL ASSEMBLY



OLD NEW

ONE 9" BEVELED RING REPLACES 15 BOLTS—In addition to functioning as mechanical fasteners, the Truarc Beveled rings serve as pressure vessel closures, providing leak-proof seals. The wedge action of the ring compensates for wear, provides a constant tight seal.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

Statistically Controlled Quality from engineering and raw materials to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today . . . let our Truarc engineers help you solve design, assembly and production problems . . . without obligation.

WALDES

TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C.1, N.Y.
Please send new, descriptive catalog showing all types of Truarc rings and representative case history applications.

(Please print)

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

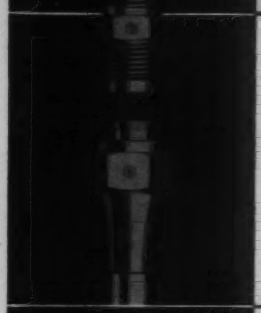
MD-080

Consult the Yellow Pages of Your Telephone Directory for Name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

Circle 459 on Page 19

Important Engineering Information

BRASS TUBE FITTINGS

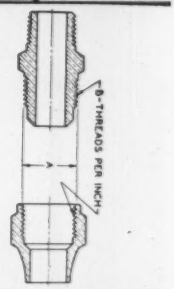


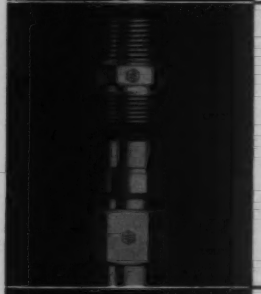
WEATHERHEAD S.A.E. 45° FLARE

Listed by U. L.; approved by A.G.A. Meets specs of SAE Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping. USED with copper, brass, aluminum, Bundyweld and plastic tubing. PRESSURE RATING: from 750 p.s.i. to 3000 p.s.i. depending on O.D.. of tube.

SIZE CHART

	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4
A	5/16	3/8	7/16	1/2	5/8	11/16	3/4	7/8	1-1/16
B	24	24	20	20	18	16	16	14	14



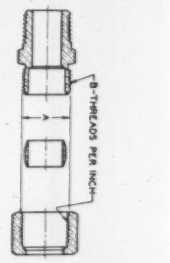


WEATHERHEAD COMPRESSION

Listed by U. L.; approved by A.G.A. Meets specs of SAE Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping. USED with copper, brass, aluminum and plastic tubing. PRESSURE RATING: from 750 p.s.i. to 2000 p.s.i. depending on O.D. of tube.

SIZE CHART

	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4
A	5/16	3/8	7/16	1/2	9/16	5/8	11/16	13/16	1
B	24	24	24	24	24	24	20	18	18

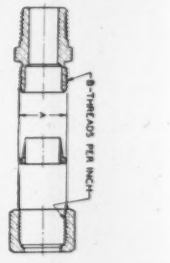


WEATHERHEAD SELFALIGN®

No flaring, soldering, welding, or special tube preparation needed with Selfalign. USED with copper, brass, aluminum and plastic tubing. PRESSURE RATING: from 1000 p.s.i. to 2000 p.s.i. depending on O.D. of tube.

SIZE CHART

	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4
A	5/16	3/8	7/16	1/2	9/16	5/8	11/16	13/16	1
B	24	24	24	24	24	24	20	18	18

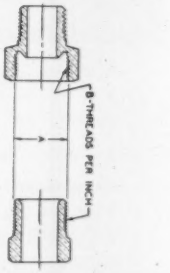


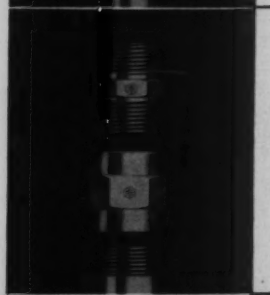
WEATHERHEAD INVERTED FLARE

Listed by U. L. Meets specs of S.A.E. Hydraulic Tube Fittings and A.S.A. and A.S.M.E. codes for instruments and control piping. USED with copper, brass, aluminum, steel, Bundyweld and plastic tubing. PRESSURE RATING: from 800 p.s.i. to 3000 p.s.i. depending on O.D. of tube.

SIZE CHART

	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4
A	5/16	3/8	7/16	1/2	5/8	11/16	3/4	7/8	1-1/16
B	28	24	24	20	18	18	18	18	16



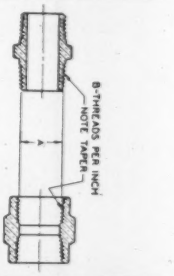


WEATHERHEAD PIPE

Meets specifications of S.A.E. TPHL Fittings Committee. USED with brass or steel pipe. PRESSURE RATING: up to 5000 p.s.i. depending on size of pipe.

SIZE CHART

	1/8	1/4	3/8	1/2	3/4	1
A	13/32	9/16	11/16	27/32	1-1/16	1-5/16
B	27	18	18	14	14	11-1/2



WEATHERHEAD

Write For Complete Catalog

THE WEATHERHEAD CO., FORT WAYNE DIVISION

Dept. AB-8, 128 West Washington Blvd., Fort Wayne, Indiana

In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

MACHINE DESIGN
August 7, 1958

Toward a B.D.E.

THE ENGINEER who chooses the fascinating field of machine design quickly learns that the traditional mechanical-electrical - civil - chemical grouping is somewhat unrealistic. Today's engineered products — industrial and consumer—can never be designed wholly within the disciplines of just one of the four departmental designations.

So it is significant to find a distinguished practical engineer airing the notion that such designations might ultimately disappear. Jim Zeder recently described to the ASME a proposal, now being considered by some educators, to replace the existing setup with three basic departments: Energy, materials, and man.

This way of looking at things might have come straight out of Webster's dictionary, which defines engineering as "the art and science by which the properties of matter and the sources of power in nature are made useful to man in structures, machines, and manufactured products."

It should strike a responsive chord in design engineers. They are deeply concerned with energy and power. While specialists develop the sources of power with engines, turbines, generators, nuclear reactors, etc., the general practitioners apply the resultant energy to machine drives and controls in all forms — mechanical, electrical, fluid power.

Design engineers live by materials. Basic materials, fabricated parts, components—these elements enable the designer to apply the art of engineering to translate the science into actual hardware.

Usefulness to man is only part of the "man" picture. As his supervisory and management responsibilities increase, the engineer finds himself more and more concerned with the techniques of organizing people to get things done.

Discerning readers of MACHINE DESIGN will recognize that our publishing approach is based on the foregoing three elements. Building on readers' B.M.E. or B.E.E. backgrounds, we offer, in effect, a postgraduate course that should qualify the faithful student of our pages for a degree of Bachelor of Design Engineering.

Colin Carmichael

EDITOR

How to plan and organize for NEW-PRODUCT

By PHILIP R. MARVIN
Manager
Research and Development Div.
American Management Association
New York, N. Y.

The future success of most companies depends largely upon new-product development. Both on a company and on a departmental basis, however, the future must be accommodated by planning and organizing today. This article underlines the role of future planning, and then shows how to organize jobs, functions, and responsibilities to provide a team that is geared to tomorrow.

PRODUCT-development operations need sound planning and organization as much as any other operation. Firms who want new products must be set up to handle them. Any product-development goal can be reached if it is defined, an approach is planned, the right organization is set up, and the proper people are selected. Setting up, or correcting, an organization so that it suits tomorrow's plans and demands is one of management's greatest challenges, but the path to success is blazed no more sharply today than it was years ago.

One of the tragedies of "good times" for business is the tendency to neglect forward planning. When times are good, management believes it possesses a sixth sense which can lead it only to success. In poor times, everything except inadequate planning is blamed.

Because of the uncertainties of forward planning, it may seem like an academic exercise—but it pays off handsomely for those who have enough courage and know-how to apply it. Most of the rules for successful planning can be learned from those who have been successful.

1. Plan no farther ahead than business trends can be projected.
2. Revise plans occasionally, as new data are developed.
3. Since decision and action are responsibilities that may warp impressions, listen to those who are not so close to the problem. Patterns and forces may be more visible to informed sources outside the department, business, or industry.
4. Do not expect the future to be like the plans. Plans should assume risk, and not be misled by historical bookkeeping figures that look foolproof.
5. Remember that businesses exist only to sell.
6. Forward planning is essential for both big and small business.

Mr. Ralph Cordiner, president of the General Electric Co., said in his recent book *New Frontiers For Professional Managers*, "In a time of radical world-wide change, when every day introduces new elements of uncertainty, forward planning may seem to be nearly impossible—an exercise in futility. Yet there never was a more urgent need for long-range planning on the part of every business, and indeed every other important element of our national life."

Growth-Product Relationships

Forty-one of the companies that were among the "100 largest" in 1926 have since disappeared from the list, according to The First National City Bank of New York. Worth noting is that size gives no protection. The wholesale shift—41 per cent—of industrial leaders shows changes caused by national growth, competition, changing habits in public demand, and shifting levels in managerial ability.

Most of the companies that dropped out of the 1926 list were in older industries, where growth had slowed down. Of the 41 companies replacing them, most are in newer, fast-growing industries.

When attention is diverted by labor unrest, tax problems, sales efforts, merges, and other pressing demands created by today's business, the company's product is sometimes ignored. Yet, the product is the basis of the business. When products are pushed into the background, growth ceases.

Today's products have a big job ahead of them. Excess capacity looms large in relation to current demand. Since the end of 1956, over-all production

DEVELOPMENT

. . . to assure a successful tomorrow

has slipped from an estimated 85 to 81 per cent of capacity—its worst since 1954. New products are the key to new selling spurts.

The current excess capacity does not alter long-range projections for the economy. It does create opportunities for alert companies. Walter Hoadley, vice president and treasurer, Armstrong Cork Co., has remarked that ". . . though we haven't revised our goals for 1962, we recognize that we'll have to put in more effort than expected to reach them."

Charles Percy, president of Bell and Howell, revealed that 65 per cent of sales come from products that were not even known five years ago—and today, the company is spending more time than ever before looking for new products.

Annual reports emphasize that over 80 per cent of the sales volume in a number of growing companies comes from products that were unknown ten years ago. These are not just figures taken from reports of new companies; these patterns are found in all growth businesses, from small corporations to industrial giants.

Organization Planning

Management rarely has a chance to build an organization from scratch. Usually the problem is to fix up a going organization. Fuzzy chains of command, undefined responsibilities, and lack of authority cause organizational patterns that look more like webs than charts. Two reasons stand out. First, those who set up the organization had no plan. Second, the organization was not kept up-to-date.

With the right start, organization planning poses no impossible problems. Setting up goals is the starting point. Without them, any other efforts are meaningless. Once the goal is known, the planning can start.

It makes no difference at this point whether the problem is to organize or to reorganize—both start with pinpointing the goals. A common mistake is to look around to see what others have done and to test some of their ideas on a trial-and-error basis. This is a good way only to waste time.

Value of Specialization

A gas-station owner once bragged about being one of the few independents left. He said he was not going to sign up with any chain and have a lot of outsiders telling him how to run his station. Like others, he was not doing half as well as he knew how—so why learn more. Almost everyone has heard such ideas—and if one is honest, one will probably admit to feeling the same way at times. Certainly this is true with company planning.

In looking for new and different ways of doing things, there is a tendency to lose sight of fundamentals that have been known for years, and to end up not doing half as well as one already knows how, while breaking all records studying new methods.

Most businesses can improve by weighing their operations and seeing how much use they are getting from grouping similar activities. Executives commonly worry about who reports to whom—each chief wanting the most Indians. Usually, the result is chaos.

Definition of Important Jobs

Do not, when organizing or reorganizing, jump right into an analysis of the chain of command. Instead, look first at the individual jobs that must

be done. Each company is different. These differences come from industry patterns, types of customers, and the requirements of the technologies involved. No one knows these better than management. The only help in sorting out jobs essential to new-product development is an indication of the job areas that must be studied. Any company, to develop new products, must work in eight areas:

1. Set up objectives
2. Develop policies
3. Plan for future
4. Program research
5. Program engineering
6. Plan products
7. Forecast sales
8. Plan production

These jobs must be done if new-product programs are to be successful. Things that must be known are: Who does the work? Who helps? Who should know about it? Who approves it? These relationships are basic to any product development. An easy way to see if they are provided is by developing a functional-organization chart.

Functional-Organization Chart

The functional-organization chart is an important tool. Relationships, once established, can be shown in the familiar line-and-box diagram. The chart then shows the relationship between the functions and the amount of responsibility involved in each.

With the chart, organizational problems can be seen in proper perspective. The common question of whether Joe should report to Bill or to Pete can be solved according to the specific jobs involved and how these jobs fit the pattern, without reference to the individual personalities concerned.

Everyone has a job to do and the job itself is more important to the company than the man who does the job. Since the jobs must be done on a continuing basis, men must be picked to be sure that the jobs are done right. Profit-minded shareholders look for companies that are built around necessary activities, not around prima donna personalities.

To show how to use the functional-organization chart, the eight basic functions in product development are shown on a typical chart, Fig. 1, listed at the left-hand side. Functions are grouped together and listed in the general order followed in operation. The amount of responsibility involved for each function is shown, along with who does the work, who helps, who should know about it, and who approves it.

Following this plan, charts can be worked up for any operation. Such charts are not limited to basic administrative jobs. They should be used in study-

Fig. 1—Functions and jobs can be matched by use of the functional-organization chart. The chart establishes who does what and where the lines of responsibility lie.

Functional – Organization Chart

Function	Board Action	Executive – Officer Action						
	Directors	President	Development	Engineering	Finance	Manufacturing	Research	Sales
Establish Objectives	1	3	3	3	3	3	3	3
Develop Policies	2	1	3	3	3	3	3	3
Long-Range Planning	2	1	3	3	3	3	3	3
Research Programming	X	2	3	3	X	3	1	3
Engineering Programming	X	2	3	1	X	3	3	3
Product Planning	X	2	1	3	X	3	3	3
Sales Forecasting	X	2	3	3	X	3	3	1
Production Planning	X	2	3	3	X	1	3	3

Code: 1–Does the Work 2–Approves Programs 3–Should Contribute X–Should Keep Informed

ing the work of everyone in the corporation and every job performed.

Since job assignments in a company are already established, to assure objectivity a functional-organization chart should be prepared which ignores the present setup. Then this can be followed by a chart that shows the existing company pattern. Comparison shows the desirable changes.

The functional-organization chart is nothing more than a management tool. It does not and cannot tell what to do but it does show existing relationships clearly and helps in decision making. Who does what is shown clearly, so that a rapid analysis of existing relationships can be made.

For example, those who help in programming engineering are shown in the shaded horizontal area on the sample chart. In the same way, the jobs in which engineering management participates are shown by the shaded vertical column.

The functional-organization chart places emphasis on the job. The line-and-box diagram focuses attention on the chain of command. It should be remembered that the chain of command becomes important only after the job has been established.

Each job is defined by asking what work is done, what programs are approved, what help is given to the work of others, and what information is needed from other jobs.

Trouble Makers

Problems should be expected in any project and organizational assignments are no exceptions. Many of the difficulties in organizing product-development come from three common personalities that can be found in every company—large or small. These characters are the line-and-box artists, the band-wagon boys, and the new-idea pallbearers. Each must be spotted and considered in order to clear the way for effective work.

Line-and-Box Artists: These men can create many stumbling blocks in organization planning. They are public enemies of business, like the paper shufflers and the eye-shade bookkeepers who keep their eyes glued on the postage-stamp and petty-cash box while thousands of dollars may be wasted by inefficiency. The line-and-box artist not only starts the mischief, but he keeps it hidden in a cloud of organized confusion.

He is the executive who solves his problems by rearranging boxes on the organization chart and reconnecting them with new lines. He needs nothing more than a ruler, pencil, and piece of paper to create complete chaos. Once he gets control of a situation, it is nearly impossible to restore order because the organization is shifted so rapidly that solid facts are hard to find.

The important thing to remember in organizing product development is that fact-gathering and analysis must come before the organization charts. The charts are merely shorthand for recording the result.

Band-wagon Boys: When a flash of genius proves to be a money maker, the really bright boys may be killed off in the stampede that follows. Once management's support is assured, everyone tries to climb on the band wagon. Everyone wants it known that he alone had the foresight that made the new product possible.

In the dark night that comes before the dawn of success, those working on development of new products must expect skepticism, suspicion, and sabotage—but all this is miraculously transformed into wholehearted support the instant success is in sight. Human nature being what it is, one cannot ignore these facts of life. But if they are recognized, programs can be organized to withstand those who will not get behind a new idea before it is proved a success.

New-Idea Pallbearers: Some years ago, an executive in the electrical industry told a member of his staff, who suggested that the development of a static-electric generator offered considerable promise, "We know all that we need to know about static electricity. You're living in the past." A year or two later, a competitor started work on such a device and today that competitor's leadership position in nuclear-propulsion equipment is due largely to this earlier work.

Negative thinking serves only as a way out of responsibility. Observe people in conversation. When a new idea is advanced, how do they react? Do they say, "This sounds interesting. I want to look into it." Or do they say, "I doubt that we could use it, but if you want to do more work on it, let me know if you come up with anything worthwhile."

Are you a positive thinker or a negative thinker? Do you build ideas, or do you tear them down? These are important questions. Product development is always based on positive thinking. Only those who are fired with enthusiasm from positive thinking should be associated with product development.

Morehead Patterson, president of the American Machine and Foundry Co., is largely responsible for the triumph of that company's very successful and profitable innovation, the automatic bowling-pin spotter. His personal conviction that it could be developed to where it would play an important role in sales provided the drive that carried the program over innumerable hurdles. Positive thinking is the basis of success—the catalyst that turns performance into profits.

Organization Problems

An organization chart based on job analysis must be tailored with the same critical eye that went into

the operations analysis itself. It should strike the best balance in using, changing, or accepting the factors involved. At the same time, it must be remembered that each change from the ideal is a compromise with efficiency.

Some are unhappy because they cannot be given model-organization charts that will solve their problems for them. If this were possible, such charts would be offered. If it were even possible to come close to making something useful, they would be offered.

One of the great pitfalls is the tendency to be influenced by the solutions found by someone else, without taking the time to find out why this solution worked. Organizations should be designed and tailored to specific needs. They cannot be borrowed.

Organization Analysis

No one can tell which type organization is best suited to individual needs without a careful analysis. Moreover, there are very real dangers in hiring someone from outside to do this. Organizations are developed to meet specific needs in a constantly changing environment. Since today's needs give way to tomorrow's changed outlook, the organization must be flexible enough to meet the new demands. Changes must be made promptly by those close to the scene of action—by managers who understand the meaning of new developments on the horizon and who must accept the responsibility for changes or for action taken too late.

This is difficult for someone from outside because of the risk of skimming the problems involved. Consultants who accept full-time assignments recognize this. James O. McKinsey, a familiar figure in the consulting field, moved to an executive position in the Marshall Field organization in Chicago. He commented, "Never before in my whole life did I know how much more difficult it is to make business decisions myself than merely advising others what to do in their businesses, without having to take the final responsibility myself."

Organizations must fit current needs and those of the foreseeable future. As rapidly as the outlook changes, organizational adjustments should be made to suit these changes. This calls for on-the-spot action. Executives must be trained to make these changes with the best timing.

Organization Development

Effective organizational development comes from knowing the goal and how to reach it. To force new life into product development, a planned nine-step program is essential:

1. Plan forward
2. Recognize growth-product relationships
3. Follow a planned program
4. Make use of specialization
5. Define important jobs
6. Develop a functional-organization chart
7. Spot the trouble makers
8. Face organization problems realistically
9. Maintain a continuing organization analysis

In the final analysis, development must fit the individual firm. Careful performance of these nine steps can help the tailoring process and put new life into the company's all-important, product-development program.

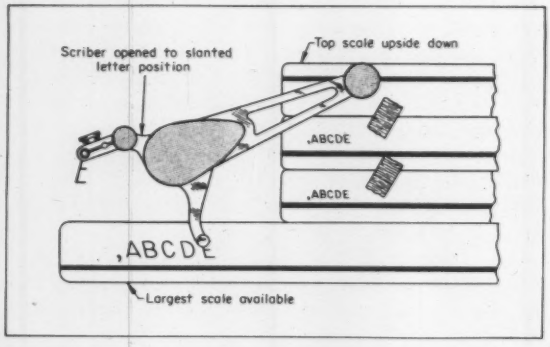
Tips and Techniques

Lead Breaking Preventative

To insure against breaking leads when using a rotary pencil pointer, slip a 5/16-in. ID O-ring over any standard automatic drafting pencil. This acts as a bearing surface for the pencil when in the pointer and prevents breaking.—GERALD H. EDISON JR., *Wethersfield, Conn.*

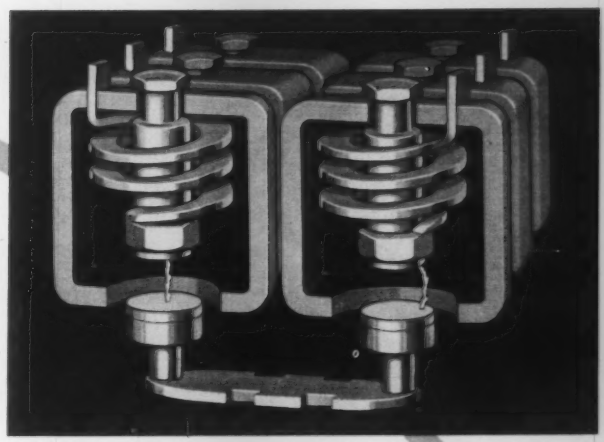
Extending LeRoy Letters

By simple arrangement of a few guides, it is possible to double the letter size on the largest available LeRoy lettering guide. Three guides are placed on top of the guide containing the largest letters, with the top guide turned upside down so the guide line is on top. The lettering instrument is opened to the slant letter position and the line follower is placed in the uppermost guide line. The letters are made by tracing the letters on the largest guide with the letter scriber.—JOSEPH E. LESCOVICH,



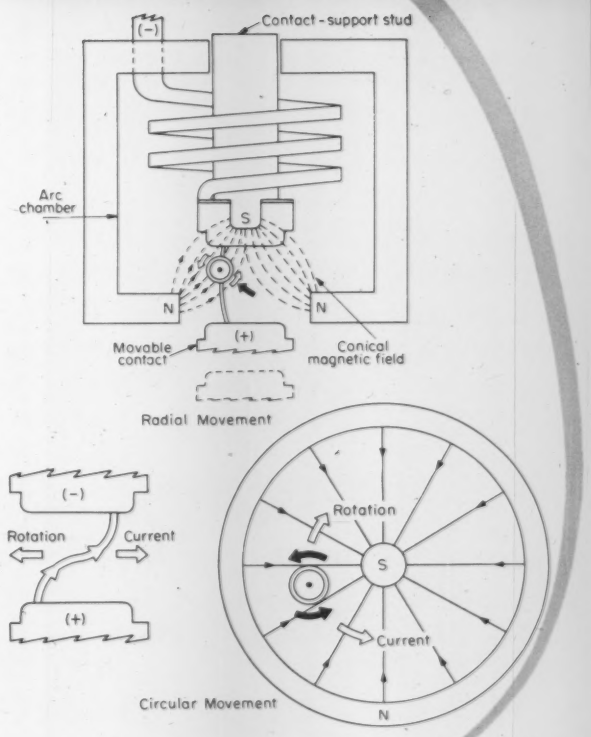
Golden Anderson Valve Specialty Co., Pittsburgh, Pa.

scanning the field for *ideas*

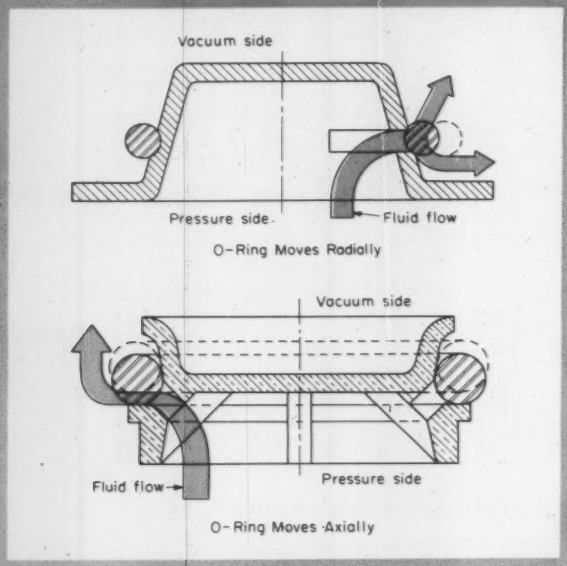


Maximum contact life under heavy current loads and severe arcing conditions is achieved in a design that employs a conical magnetic field to create a spiral path for arc "quenching." In a motor-starter construction employed by Clark Controller Co., the contact-support stud and arc chamber form a magnetic circuit, producing a conical magnetic field around the contacts. The arc, being a conductor, has a magnetic field which reacts with the main field, tending to cause movement of the arc along a circular path. As the arc moves, it is lengthened, introducing a horizontal component of current flow relative to the main field. This component results in a force toward the edge of the contacts.

The resultant of the two forces, rotational and outward, is a spiral arc path from the center to the edge of the contact face. Depending upon polarity of the half-cycle of alternating current during which the arcing occurs, the arc moves along the spiral either toward the center or the edge of the contact. Over a large number of operations, half of the arcs will strike during one half-cycle and break at the outer portion of the contact face. The other half of the arcs will strike during the opposite half-cycle and break at the inner portion of the contact face. Constant movement of the arc during quenching, and continuous relocation of the breaking point, reduce spot heating and erosion of the contact faces.

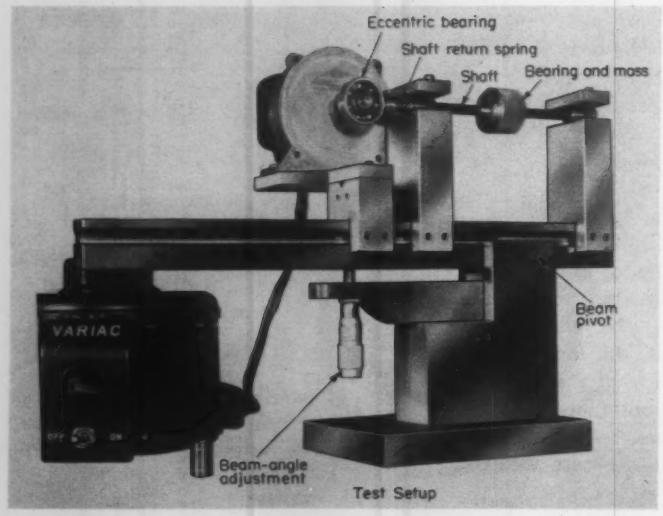


O-ring valves offer a simple but effective solution to one-way flow control in liquid passages. Developed by McMillan Engineering Service for employment in pumps, the valves consist only of a cage and the O-ring. The cage is machined on the OD to provide a seat for the O-ring. A portion of this seat is slotted to provide a passageway for fluid flow from inside the cage. Vacuum outside the cage, or pressure inside, displaces the O-ring from its seat to permit fluid flow through the valve. Depending upon design of the cage and the fluid passageway, displacement is either axial or radial.



Intraciprocation bearing system reduces frictional resistance to a minimum in instrument-bearing or similar applications requiring a high degree of sensitivity. In a design developed by Thompson Industries Inc. for linear bearings, either the shaft or the bearing is reciprocated at a relatively high frequency through a short stroke, while the other member is free to move and serves as the functional member. The magnitude and frequency of reciprocation is determined by the mass of the nonreciprocated member, which must have sufficient inertia to be unaffected by the high-frequency motion. Keeping the bearing surfaces activated at all times eliminates the need for static breakaway; thus, all resisting forces are a function of the coefficient of rolling friction.

Employed on an instrument bearing with a three-ounce mass, the principle reduced the angle necessary to roll the bearing down a shaft from 18 or 20 minutes to about one minute (equivalent force, 0.00029g).



Test Setup

Variable-Speed

Torsional-Vibration Absorber

accommodates changes in the frequency of impressed vibrations

By CHING-U IP and **IVAN E. MORSE**
Associate Professor, Assistant Professor
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IMPRESSED vibrations of a torsional system can be eliminated by adding a spring-suspended mass, tuned to the frequency of the disturbing torque. Since such an absorber works satisfactorily only if the impressed frequency remains constant, practical application is limited to constant-speed machines. For any other impressed frequency, a different absorber mass or torsional spring must be substituted.

A variable-speed absorber with a spring whose

Nomenclature

A_1 = Amplitude of vibration, main mass, rad
A_2 = Amplitude of vibration, absorber mass, rad
g = Length of air gap, in.
I_1 = Polar moment of inertia, main mass, lb-in./sec^2
I_2 = Polar moment of inertia, absorber mass, lb-in./sec^2
i = Current in field coil, amp
k_1 = Torsional spring constant of main shaft, lb-in./radian
k_2 = Torsional spring constant of absorber spring, lb-in./radian
l = Axial length of absorber rotor, in.
m = Mass of eccentric weight, lb-sec^2/in.
N = Total turns of wire in both field coils
r = Radius of absorber rotor, in.
r_1 = Radius of eccentric mass from gear center, in.
T_m = Maximum amplitude of forcing torque, in.-lb
t = Time, sec
θ_1 = Angle of vibration, main mass, rad
θ_2 = Angle of vibration, absorber mass
θ_1'' = Second time derivative (angular acceleration) of θ_1, rad/sec^2
θ_2'' = Second time derivative (angular acceleration) of θ_2, rad/sec^2
ω = Forcing (impressed) frequency, rad/sec
ω_1 = Natural frequency, main system, rad/sec
ω_2 = Natural frequency, absorber, rad/sec

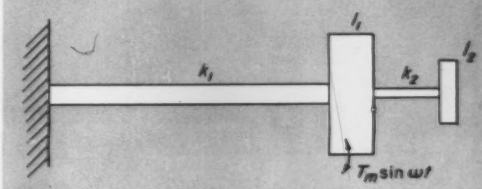

Fig. 1—Frahm dynamic absorber is a well-known solution for impressed vibrations in torsional systems but is limited to constant-frequency applications

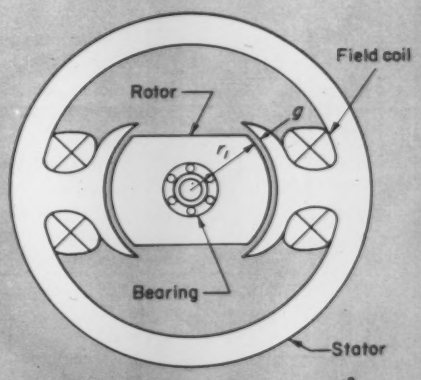

Fig. 2—When the field coil of the electromagnetic system is energized, the rotor acts as a torsional spring and mass

stiffness varies with the square of the impressed frequency can be achieved by using an electromagnetic "spring." This permits "tuning" the absorber across an entire range of impressed vibrations to permit absorption throughout the range. The stiffness of an electromagnetic spring varies with the square of the field current of the electromagnet. Therefore, adjustments in the field current are made proportional to variations in the impressed frequency.

Equations of Motion: The Frahm dynamic absorber for torsional vibrations is shown in Fig. 1. The disturbing torque is $T_m \sin \omega t$; T_m may be either a function of ω or a constant. By use of $\theta_1(t)$ and $\theta_2(t)$ as angles of vibration of the main mass and the absorber mass, the equations of motion are

$$I_1 \theta_1'' + k_1 \theta_1 + k_2(\theta_1 - \theta_2) = T_m \sin \omega t \quad (1)$$

$$I_2 \theta_2'' + k_2(\theta_2 - \theta_1) = 0 \quad (2)$$

whose steady-state solutions are

$$\theta_1 = A_1 \sin \omega t \quad (3)$$

$$\theta_2 = A_2 \sin \omega t \quad (4)$$

where

$$A_1 = \frac{(T_m/k_1)[1 - (\omega^2/\omega_2^2)]}{[1 + (k_2/k_1) - (\omega^2/\omega_1^2)][1 - (\omega^2/\omega_2^2)] - (k_2/k_1)} \quad \ldots\ldots (5)$$

$$A_2 = \frac{T_m/k_1}{[1 + (k_2/k_1) - (\omega^2/\omega_1^2)][1 - (\omega^2/\omega_2^2)] - (k_2/k_1)} \quad \ldots\ldots (6)$$

with

$$\omega_1 = \left(\frac{k_1}{I_1} \right)^{1/2} \quad (7.1)$$

$$\omega_2 = \left(\frac{k_2}{I_2} \right)^{1/2} \quad (7.2)$$

If $\omega_2 = \omega$, that is, the natural frequency of the absorber is the same as the impressed frequency, then $A_1 = 0$, or the main mass will have no vi-

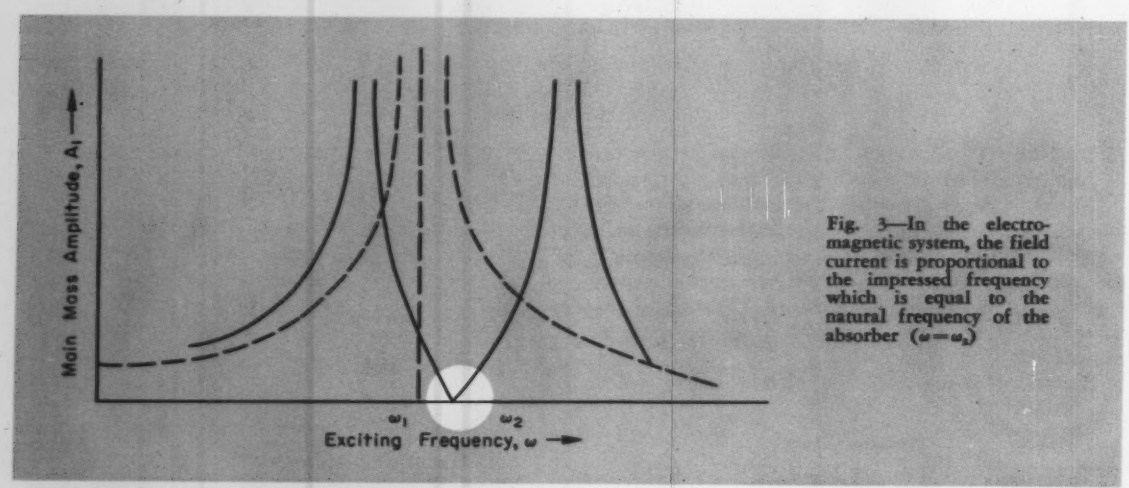

Fig. 3—In the electromagnetic system, the field current is proportional to the impressed frequency which is equal to the natural frequency of the absorber ($\omega = \omega_2$)

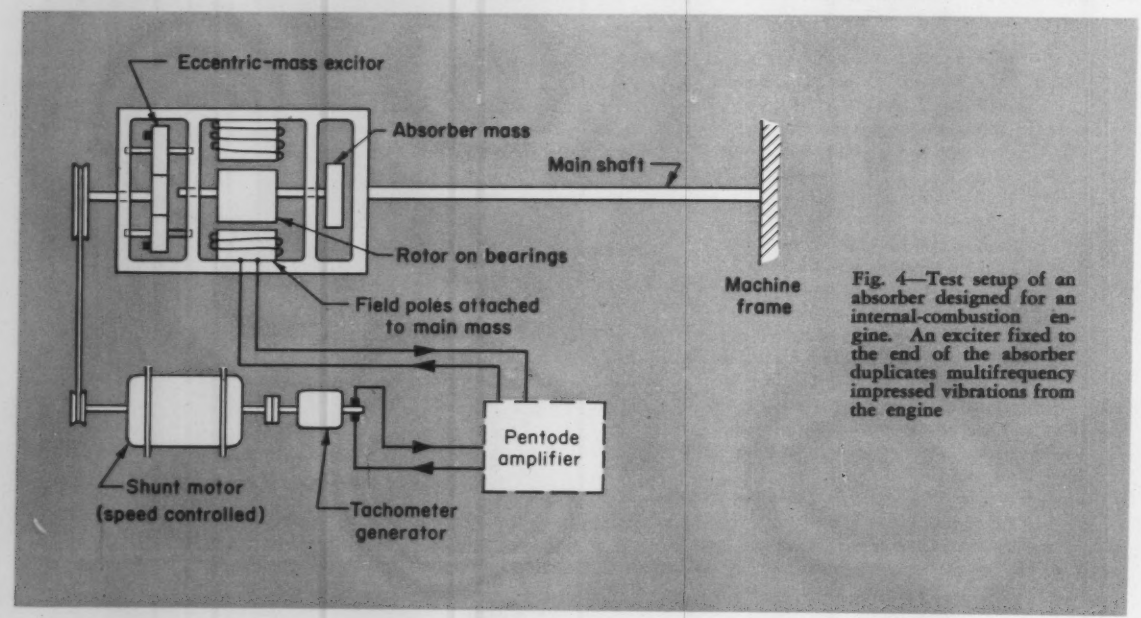

Fig. 4—Test setup of an absorber designed for an internal-combustion engine. An exciter fixed to the end of the absorber duplicates multifrequency impressed vibrations from the engine

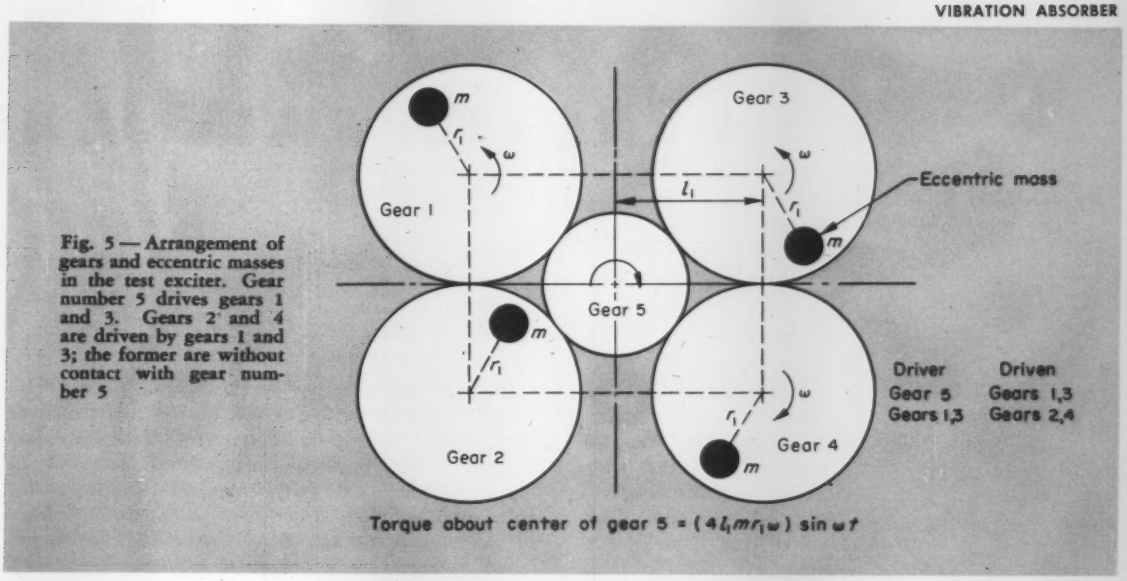

Fig. 5 — Arrangement of gears and eccentric masses in the test exciter. Gear number 5 drives gears 1 and 3. Gears 2 and 4 are driven by gears 1 and 3; the former are without contact with gear number 5

bration. Thus, from Equations 5, 6, and 7 the following developments are obtained.

$$k_2 = I_2 \omega^2 \tag{8}$$

and

$$I_2 = \frac{T_m}{A_2 \omega^2} \tag{9}$$

Equation 8 indicates that the absorber spring should have a stiffness proportional to the square of the impressed frequency. Equation 9 is used to find the size of the absorber mass because it relates the moment of inertia, I_2, of the absorber mass and the permissible absorber amplitude, A_2. This amplitude has an upper permissible value in the case of the electromagnetic spring because the spring constant, k_2, is linear only for small oscillations.

Electromagnetic Spring: Cross section of an electromagnetic system is shown in Fig. 2. The inner member of the system is free to rotate about its axis. Upon energizing the field coil in the stator, the rotor acts as a torsional spring and mass. The spring constant, k_2, is given by

$$k_2 = \frac{[(r + (g/2)]l(Ni)^2}{14.15 \times 10^6\, g} \text{ (lb-in./radian)} \tag{10}$$

where Ni is the magnetomotive force across both air gaps together (ampere-turns). This equation indicates that the spring constant, k_2, is proportional to the square of the field current, i, and this fact has been verified experimentally.

Both rotor and stator should be laminated steel for minimum eddy-current damping. If the field current is proportional to the impressed frequency, the entire system will operate at $\omega = \omega_2$, Fig. 3. As ω changes, ω_2 also changes. Theoretically, this system is an ideal vibration damper.

Absorber Test Setup: A method of testing the principles involved is shown in Fig. 4. Exciting torque is supplied by the eccentric-mass exciter which is driven by a shunt motor. The eccentric-mass exciter is shown schematically in Fig. 5. All the gears, other than number 5, are of the same size. A weight, m, is attached at a distance, r_1, from the center of gears numbered 1 through 4. The impressed torque about the shaft of gear number 5 will then be

$$T = T_m \sin \omega t = (4 l_1\, m r_1\, \omega) \sin \omega t \tag{11}$$

The shunt motor also drives a tachometer generator which generates a current proportional to the speed—and thus to the exciter frequency. The current, after being amplified by a pentode amplifier, is fed into the absorber field coils.

Higher Harmonics: Since the system is linear, the higher harmonics can be considered as separate torques acting on separate absorbers and the results can be added together. Specifically, for the second harmonic, the second absorber spring has a spring constant of

$$k_2' \propto (2\omega)^2 \propto \omega^2$$

Therefore, each of these springs has a spring constant proportional to the square of the fundamental exciting frequency. The same vibration absorber can handle any exciting torque having harmonics simply by adjusting the potentiometer in the pentode amplifier.

Applications: The absorber can be designed to eliminate crankshaft vibration of an internal-combustion engine. In the test setup, the shunt motor, belt and pulleys, and eccentric-mass exciter furnish a representation of the first harmonic of the excitation torque of such an engine. Since the absorber also works for the higher harmonics, it can be designed for any individual engine without difficulty. In this application, the main shaft, Fig. 4, represents the elastance of the crankshaft of the engine. If the subject is an automobile engine, the tachometer generator and pentode amplifier may be replaced by the automobile generator if it offers current output that is proportional to the speed.

PLASTIC BALL AND

By JOSEPH E. MONTALBANO
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ADVANTAGES which can be gained by using plastic components in ball and roller bearings are comparable to those achieved in the past by successful application of plastics in sleeve bearings, retainers, and separators. Performance of plastic balls, rollers, and races indicates that these components can withstand severe radial, axial, and impact loads, and are economically feasible from both the design and maintenance standpoints.

Reduction in noise level during operation, and excellent corrosion resistance of plastic bearing components are a few of the benefits directly attributable to inherent characteristics of the plastic. A combination of steel balls and plastic races is used in household appliances, automobiles, business machines, and in other applications where quiet operation is desirable. Grease and dirt have adverse effects on steel balls but do not impair the performance of plastic balls in steel races.

An example of early application of plastic balls with high load-carrying capacity is the main azimuth bearing for the cupola of an M-48 tank. Evaluation of all-steel bearings during development of the cupola showed that grit, deposited in the bearing during normal field operation of the tank, caused an increase in friction torque, brinelling, and maintenance difficulties. Design of the azimuth bearing using plastic balls in steel races resulted in decreased weight and cost of the bearing assembly, and in trouble-free operation of the cupola.

Design Advantages: Specification of plastic bearing-balls for applications similar to that shown in the illustrations, reduces tolerance requirements considerably for both the balls and bearing races. Normally, steel balls require tolerances of approximately ± 0.0001 in., whereas plastic load-carrying balls require ± 0.0005 in. and idler, or separator,

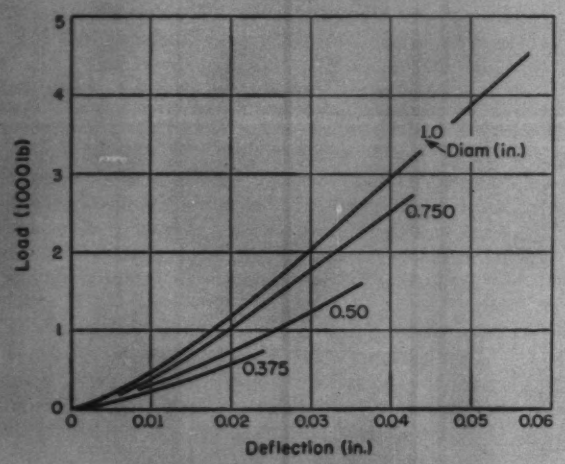


Fig. 1—Load deflection of melamine bearing balls. Balls are loaded between flat, hardened-steel plates

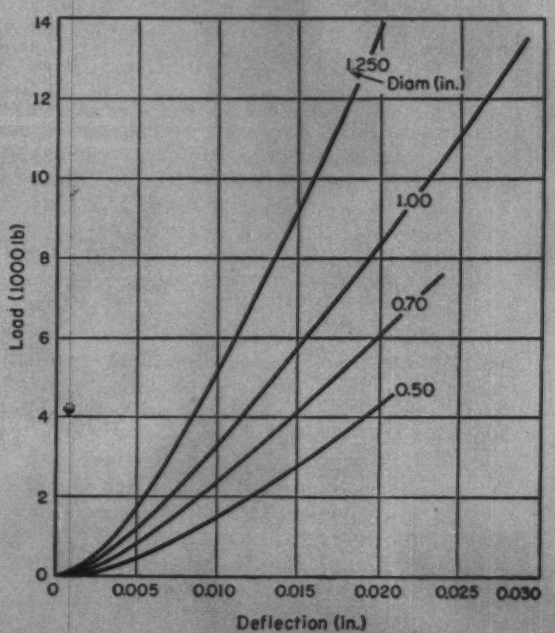


Fig. 2—Right—Load deflection of plastic rollers also loaded between steel plates

ROLLER BEARINGS

- **Advantages**
- **Applications**
- **Limitations**

balls only ±0.001 in. The natural resiliency of plastic balls allows relaxed tolerances on steel races. For example, a 30-in. diam plastic-steel bearing requires a TIR of only 0.003 in. The steel races do not require additional surface hardening and do not need to be lapped and polished. However, some of the more highly loaded bearings having steel races and plastic bearing balls do generally require heat treatment of the races.

Because plastic balls remain unaffected by dirt and grit, and are impervious to corrosion, bearing sealing problems are much simplified. For rotational speeds under a 500-fpm pitch-line velocity, no lubrication is necessary. At higher rotational speeds, lubricants are used primarily as coolants.

Bearing Materials: Applications of plastic bearing-components appear to be limited only by the number of available plastic materials and the inherent properties of each. Phenolic cast into rods, cut, and centerless ground to a tolerance of ±0.005 in. on the diameter proved adequate for the balls of the azimuth bearing. After postcuring, a final grinding operation removed the hard surface and reduced the tolerance to ±0.0005 in. Post curing is often erratic, however, and removal of the hard surface by finish grinding may cause load-carrying ability of the balls to vary by as much as 100 to 200 per cent.

Cast-phenolic load-carrying balls, 0.406 in. in diameter, withstand a 200-lb load between flat plates before permanent set takes place. Ultimate failing values for these balls may range from 425 to 1000 lb depending on postcuring operations. Adequate quality control will insure an average failing load of at least 750 lb.

More than 100 plastic materials were evaluated to determine their suitability for bearing components. The materials, tested with a variety of fillers, in-

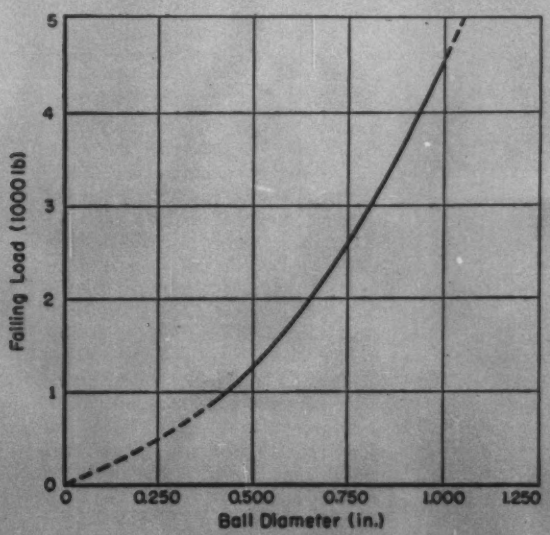


Fig. 3—Failing Loads of melamine balls. Curved grooves in bearing races can increase the failing-load value by 40 to 50 per cent. Deflection characteristics of plastic balls dictate relatively shallow grooves

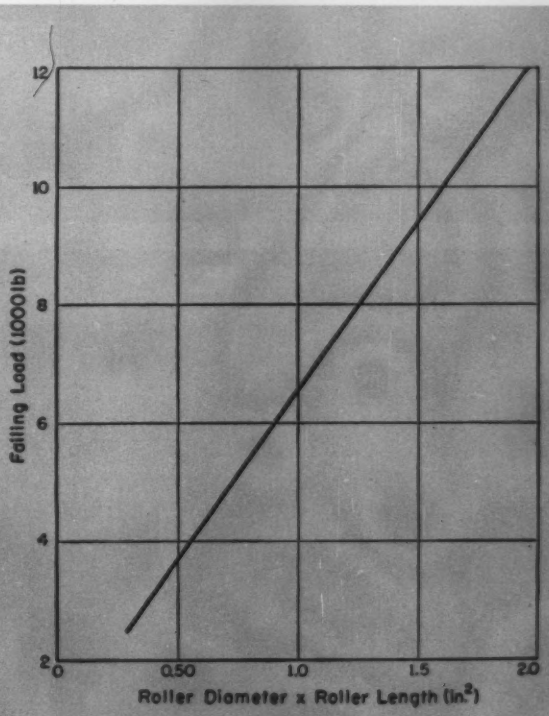


Fig. 4—Right—Failing loads of plastic rollers

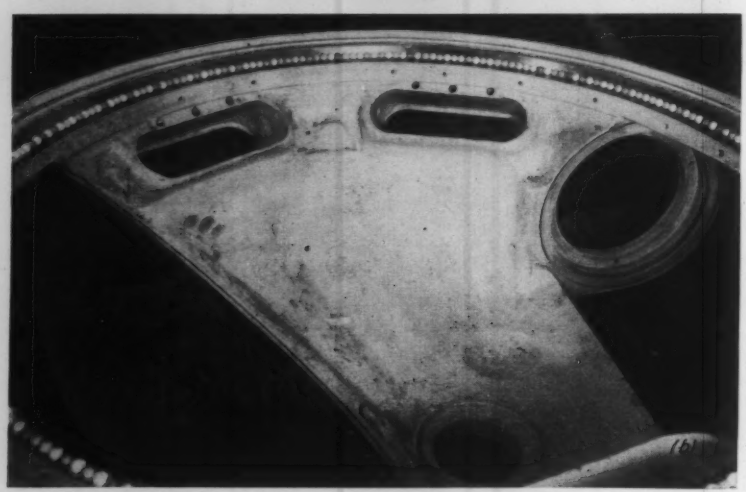
cluded molding compounds of urea, melamine, phenolic, and alkyd, and casting compounds of phenolic and epoxy. A comparison of the eight most promising materials showed that unfilled compounds are superior to filled compounds for virtually all evaluation tests. Unfilled-resin compounds show better resistance to water absorption and chemical attack than filled compounds. Fig. 1 shows typical deflection curves for melamine balls of various diameters. Deflection curves for plastic rollers are shown in Fig. 2 for comparison. Curves are based on test results and, in all cases, the ball or roller was loaded between flat, hardened-steel plates.

Producibility: Unfilled phenolic molding compounds require an extremely long curing cycle (15 min for ½-in. diam balls) and are not suitable at present for quantity production. Unfilled melamine compounds do not require as long a curing cycle but present problems with entrapment of gases during molding. Use of preforms and high-frequency preheating has solved this problem to some extent. To achieve consistent uniformity in production quantities of unfilled melamine balls, rigid quality-control procedures must be followed. Curing cycles must be controlled to prevent shrinkage cracks during finish-grinding. Use of alpha-cellulose filled melamine molding compounds overcomes these difficulties with very little sacrifice in over-all performance.

Load-Carrying Properties: An increase of approximately 40 to 50 per cent in failing-load value of plastic bearing-balls can be achieved by incorporating curved grooves in the bearing races. This increase, however, is not as great as that attained with steel balls in curved grooves.

Plastic Bearings for

Because plastic bearing components exhibit excellent resistance to shock and impact loads, 1-in. plastic balls are used instead of steel balls in the main-turret bearing assembly of a T-92 Light Tank, Fig. *a*. This bearing, approximately 90 in. in diameter, supports the weight of the main-turret and machine-gun cupolas, and absorbs all gun recoil forces and accelerations imposed during high-speed travel over all types of terrain.



A machine-gun cupola designed for an M-48 tank utilizes plastic bearing-balls in steel races for both the gun-trunnion bearing and main azimuth bearing. The cupola was subjected to more than 2000 mi of rough, cross-country travel and absorbed recoil from well over 15,000 rounds of ammunition without adversely affecting the bearings.

The double-row main bearing, of which a single row of balls is shown in Fig. *b*, is approximately 30 in. in diameter and uses 0.406-in. diam cast-phenolic balls. It supports the 1500-lb cupola which is subject to gun recoil and to vertical accelerations to 18 g. The main bearing is a full-complement type and does not require a cage. Alternate balls, slightly smaller than the main load-carrying balls, are used instead of retainers. The two sizes of balls, Fig. *b*, are of different colors for rapid identification. The single-row trunion bearing, approximately 10 in. in diameter, also uses 0.406-in. plastic balls and smaller alternate idler balls.

A main-pedestal bearing, Fig. *c*, was developed to replace a proved steel bearing on a caliber .30 gun mount for an LVT-5 Landing Vehicle. The bearing is a double row, full-complement bearing 10 in. in diameter. Load-carrying balls are 0.0406 in. and the alternate idler balls, which eliminate need for a retainer or separator, are 0.394 in. in diameter. Races are machined from linen-base phenolic tubing, are split

Relatively shallow grooves are recommended because of increased deflection which is characteristic with plastic balls. Failing-load values for plastic bearing-balls and plastic rollers are shown in Fig. 3 and 4 respectively.

Applications: To date, plastic bearings have been most useful in relatively low-speed applications, i.e., 15 rpm or 500 fpm pitch-line velocity. Recently, however, a 2-in. diam plastic wheel bearing was developed which operates successfully at rotational speeds to 1250 rpm. Lubrication is required only for heat dissipation. Also, excellent results were obtained with all-plastic bearings operating at 1250 rpm completely submerged in salt water.

Additional design data are still required before the full potential of plastic bearings is realized. Relation of load-carrying capacity to rotational speed, life expectancy, and lubrication and heat-transfer characteristics must yet be determined. However, plastic bearings are being considered for applications in which corrosion, magnetic interference, and sparking cannot be tolerated.

Limitations: Although plastic bearings have proved satisfactory for particular applications, certain factors limit their acceptance on a large scale. All-plastic bearings are not mass produced at the present time. Those that are available are larger than comparable steel bearings and require more space for given load conditions. Applications are limited to low speeds and to moderate temperatures of −65 to + 300 F. Maximum diameter of laminated tubing from which bearing races are machined is limited at present to 36 in.

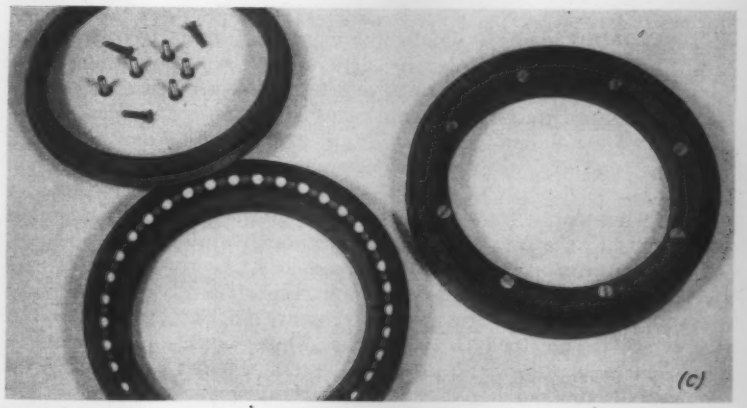
Armored-Vehicle Turrets

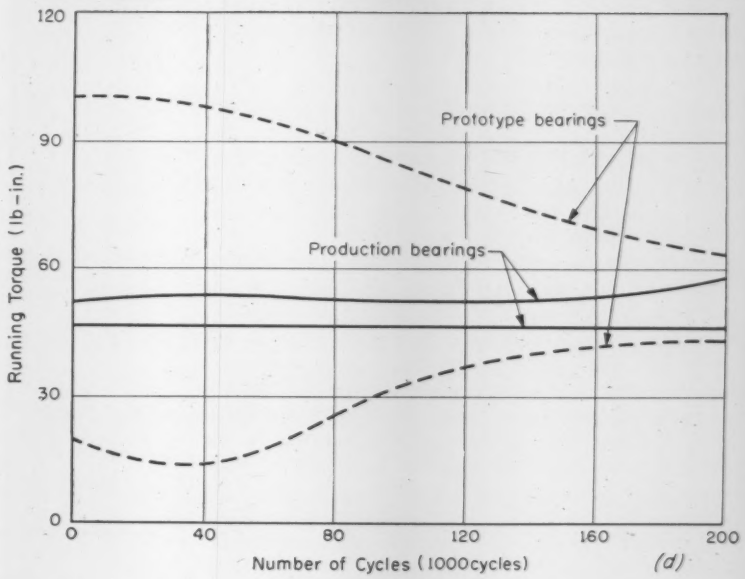
for filling, and are joined with aluminum screws. For applications which require all nonmetallic components, plastic screws are used.

Prior to acceptance, this bearing was subjected to a series of tests to determine the effects of various loads on the all-plastic assembly. The gun mount was supported as in normal vehicle installation and was rotated at 15 rpm. An impact loading of 20 ft lb at 600 cpm was applied at the trunnion during rotation to simulate recoil impact. This cyclic impact was based on calculations and actually exceeded trunnion impact obtained from a caliber .30 machine gun. Actual gun-recoil load, located approximately 14 in. above the bearing, applies both a radial load and a moment load to the plastic bearing. A 250-lb load was applied normal to the bearing to simulate turret weight under vertical accelerations equivalent to 2.5 g.

After tests which applied acceleration loads and an impact equivalent to the recoil from 1 million rounds of ammunition, the bearing showed no appreciable signs of wear or brinelling. The test conditions far exceeded those encounted during the useful life of the turret itself.

This same test bearing is still in operation after five years of demonstrations, handling and drop tests, and constant use in design mock-ups. The bearing is one-fifth the weight and, even in limited production, is one-third the cost of a comparable steel bearing. Fig. *d* shows comparative curves of two production and two prototype bearings of the type described.


(c)



(d)

THERMAL STRESSES IN DESIGN

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RATIONAL analysis, which was elementary in the treatment of brittle materials,[1,2] becomes much more complex in the consideration of thermal stresses in ductile materials. Stress equations are not readily solved, since stress is no longer proportional to strain. The fact that few problems involving plastic flow of ductile materials under thermal stress have been treated in the literature attests to the complexity of the solution.

Furthermore, since the failure process is a progressive one, and material deterioration occurs during and between thermal-stress applications, failure can rarely be obtained in one cycle. Thus, with ductile materials, the data are usually presented in the form of the number of stress cycles withstood under a given set of conditions. Only very recently has an attempt been made to approach this problem on a quantitative basis.

One of the simplest and most direct methods of describing the fundamentals, and experimentally studying the phenomenon of thermally induced fracture, is to utilize a mechanically constrained bar, Fig. 15. This bar is cycled hot and cold, so that it tends to expand and contract alternately. It is assumed, however, that the length of the bar is completely constrained by fixed end plates. In this manner, prevention of expansion or contraction of the bar produces a thermal stress. The strain associated with the stress counteracts the change in length associated with the temperature change, maintaining the total length constant. Thus, while there is no external evidence of change in length, the bar is being subjected to mechanical strain equal to the thermal strain that would result if constraint were absent.

If the bar fractures after a number of cycles of temperature fluctuations, the failure is defined as *thermal-stress fatigue*. A distinction can be drawn between thermal-stress fatigue and *thermal fatigue* in that the latter presumably occurs without the presence of either external constraint or macroscopic stress. The distortion, and even cracking, of uranium specimens[1] would be referred to as thermal fatigue, although internal stresses are present on a microscopic scale.

In this section the discussion will be limited largely to the fundamental aspects of thermal-stress fatigue of completely constrained specimens. While some reference will be made to cases of partial constraint, and to a few practical applications of the fundamental data, the principal discussion of the engineering aspects of thermal shock and thermal-

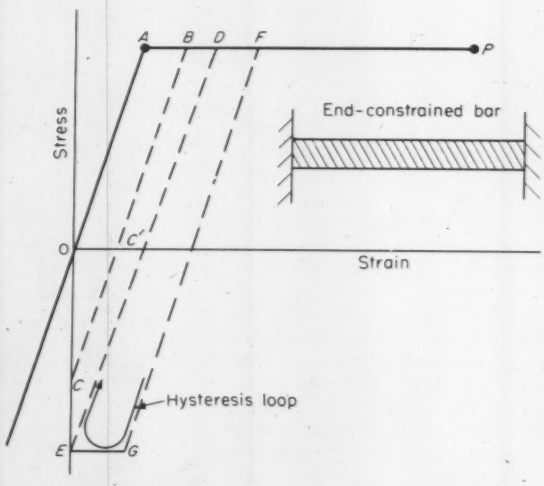

Fig. 15—Cyclic-plastic strain induced by heating and cooling a constrained bar

[1]References are tabulated at end of article.

Part 3—Basic Concepts of Fatigue in Ductile Materials

- **Stress-Strain Mechanisms**
- **Metallurgical Aspects**
- **Quantitative Analysis**
- **Failure by Plastic-Strain Cycling**

stress fatigue of ductile materials, and the design applications of such data, will be presented in later sections.

▶ Stress-Strain Mechanisms

One of the mechanisms associated with the ultimate failure of ductile materials in thermal-stress cycling is plastic flow. The role of the plastic-flow process can best be outlined by considering an idealized problem. Deviations of this model from the practical cases will then be discussed.

Idealized Thermal-Cycling Model: The end-constrained bar, Fig. 15, is assumed to be gradually cooled and heated between two temperature limits. Since it is assumed that the material is ideally plastic, its hypothetical stress-strain curve, Fig. 15, consists of a straight line up to the yield stress and a constant-stress line during yielding. Thus, stress is proportional to strain along the line OA, and further strain is induced at stress σ_A until rupture occurs at P. It is also assumed that, at the start of the process, the bar is unstressed in the hot condition, and is subsequently cooled. The bar is taken as stress-free in the heated condition to induce tensile stress during the first stage of the process. If it were not constrained at its ends, the bar would contract freely as the temperature is reduced, and there would be no stress. Because of the constraint, the length remains constant and there is induced a mechanical strain equal to the thermal expansion $\alpha(\Delta T)$. See Nomenclature. The stress will depend on this strain and on the stress-strain curve.

As long as $\alpha(\Delta T)$ is equal to or less than the strain at A, the stress is elastic and the analysis would be the same as for brittle materials. If, however, the cycling temperature range is increased to induce a thermal strain equal to that at B, the stress developed will be the yield stress, and plastic flow of an amount AB will be induced during the first cycle of temperature reduction. When the temperature is again raised to its initial value, the stress will fall along line $BC'C$. At some time during this temperature increase, there is a point, C', where there is no stress, but the strain is not zero. When the initial temperature is finally reached, the condition of the bar will be represented by point C, where the strain is zero and the compressive stress equals OC. This results from the increase in free-bar length induced by the plastic flow AB. Subsequent cycling within this temperature range would cause the material to cycle between the points C and B, and an indefinite number of cycles could be obtained without further plastic flow.

If the temperature difference of cycling produces a thermal strain, point D, twice the elastic strain,

Nomenclature

E	= Elastic modulus
K	= Material constant (determined by test)
N	= Number of plastic strain cycles to failure
n	= Material constant (determined by test)
α	= Coefficient of expansion
ΔT	= Change in temperature from reference temperature to any time interval. (Reference temperature is temperature at which stress is zero)
$\Delta\sigma$	= Stress range
ε	= Strain
ε_c	= Compressive strain
$\varepsilon_{c,p}$	= Compressive-plastic strain
ε_e	= Elastic strain
ε_f	= Fracture ductility
ε_p	= Plastic strain
$\varepsilon_{t,p}$	= Tensile-plastic strain
ε_T	= Total strain
σ	= Stress

then cycling will take place between *D* and *E*. That is, the cycling will occur between yield stress in tension and the yield stress in compression. For simplicity, the yield stress in compression is assumed to be equal to the yield stress in tension. After the first cycle, in which plastic flow does occur, an indefinite number of cycles could be applied without further plastic flow.

Finally, consider an applied temperature difference such that the thermal strain, point *F*, is greater than twice the elastic strain. As the cooling cycle is applied, the stress increases along line *OA* and elastic strain occurs; then, plastic flow occurs by an amount *AF*. As the specimen is subsequently heated, it unloads elastically along line *FG*. At *G* it still has not achieved its initial free length, because the strain is not yet zero. Therefore, as the temperature is brought back to the initial value, plastic flow in compression occurs by an amount *EG*. During the second cycle, the stress first changes from the compressive-yield stress at *E* to the tensile-yield stress at *D*, and then further tensile-plastic flow *DF* occurs. On the second unloading cycle, the material proceeds elastically from *F* to *G* and again flows in compression from *G* to *E*. Hence, every cycle induces in the bar tensile-plastic flow of an amount *DF*, and subsequently an equal amount of compressive-plastic flow *EG*. This alternate tensile and compressive plastic flow ultimately leads to failure of the material.

Superimposing Realistic Mechanisms: To approach the problem more realistically, many factors that complicate the idealized model must be recognized. Most materials show strain hardening, an increase in stress with strain after yielding, instead of proceeding at a constant stress as shown in Fig. 15. It must also be recognized that because of the continuously changing temperature, the stress-strain relation is continuously changing. Hence, it is not possible to use a single stress-strain curve to treat the problem. The stress-strain curve at the mean temperature of the cycle can be used as a first approximation, but some error is to be expected, of course.

In addition, the Bauschinger effect also enters into the analysis. This means that plastic flow in one direction reduces the stress at which yielding will occur in the opposite direction. Thus, the stress-strain loop *EDFG*, Fig. 15, should not necessarily be bounded by equal tensile and compressive stresses, because the tensile plastic flow *DF* presumably reduces the compressive flow stress σ_{EG}. This effect is superimposed on any initial tendency of the material toward different tensile and compressive flow stresses. Moreover, the two types of flow occur at different temperatures where differences in the flow stresses exist. Finally, any stress relaxation that occurs as a result of creep and inelasticity during a

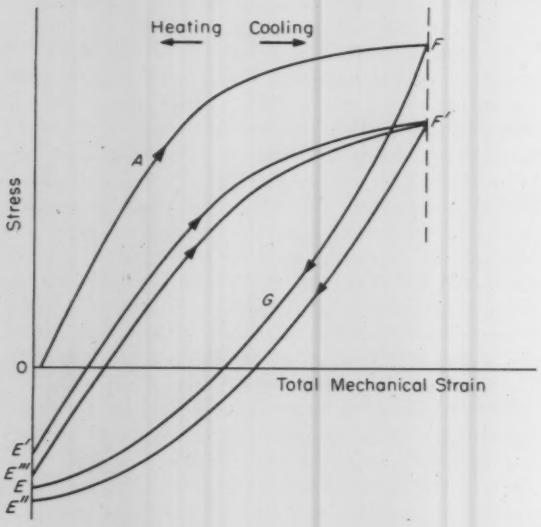

Fig. 16—Schematic stress-strain relationship for several thermal cycles

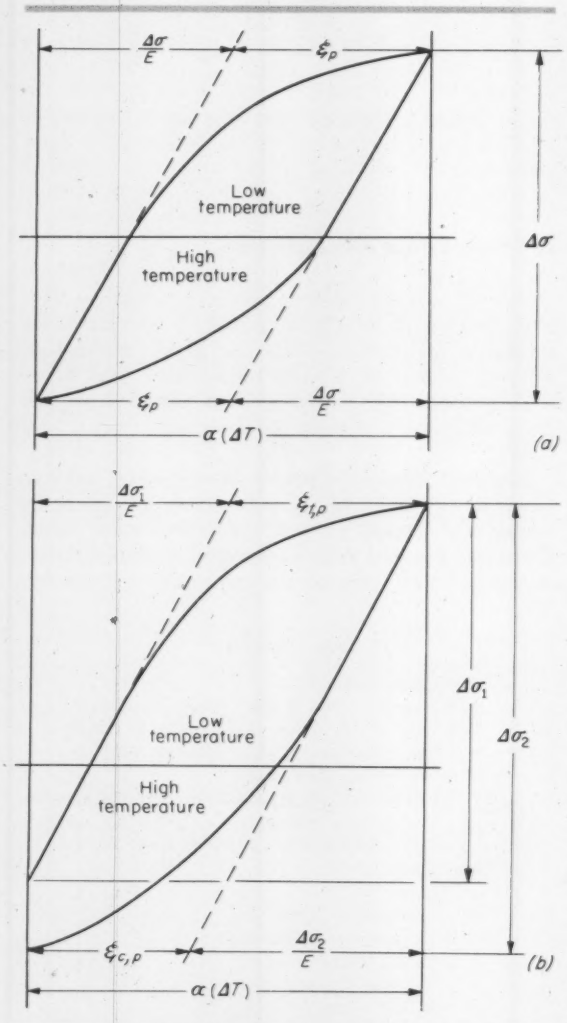

Fig. 17—Plastic-strain and stress-range relationship for, *a*, no creep relaxation during hold period and, *b*, creep relaxation during hold period

hold period, that may be imposed at high temperature, must be taken into account.

A more realistic, but still schematic, stress-strain diagram, Fig. 16, has been constructed for a constrained specimen subjected to a sufficiently high temperature variation to cause cyclic-plastic flow. The bar is again clamped when hot, so that tensile stress is developed along *OAF* during the first cooling. Plastic flow is initiated at *A*, but the stress continues to increase to *F* due to strain hardening. At *F*, the specimen is held for a dwell period, but no stress change occurs since the temperature is presumed to be low enough to make creep and inelasticity negligible. (If the temperature were higher, the point *F* would move in a manner similar to that which will be discussed later for point *E*.) Upon reheating, the stress-strain relation proceeds along *FGE*, yielding at a much lower stress, point *G*, than in the ideal case, point *A*, because of the Bauschinger effect. When the initial high temperature is restored, the state of the material is at point *E*, where a compressive strain is necessary to offset the tensile-plastic flow that occurred during *AF*, thereby returning the specimen to a net strain of zero. Part of this strain associated with the stress at *E* is plastic and part elastic.

Any hold period at high temperature and high stress may convert the elastic strain to inelastic strain, thereby reducing the stress. Thus, point *E* moves to point *E'* by the time the specimen starts to cool again. The second cooling causes the path *E'F'* to be traversed. Reheating then results in the path *F'E"*, and the hold period at the high temperature converts *E"* to *E"'*. After a few cycles, the stress-strain path may settle down to an essentially unchanging loop. For illustrative purposes this loop may be taken as *E"'F'E"E"'*. The energy dissipated during this "hysteresis" loop ultimately deteriorates the material, and produces fatigue fracture in a manner somewhat similar to that which occurs in conventional fatigue at constant temperature.

Metallurgical Aspects

Thus far, the discussion has omitted metallurgical changes that occur in the thermal-cycling process, except as they might have a direct effect on mechanical properties that alter the hysteresis loop. In many cases, the change in material metallurgy is a predominating factor which affects the thermal-stress fatigue behavior, and it is well to mention several of the important mechanisms involved.

Aging: Probably the most important action that takes place during and between thermal-stress tests is that of aging. Most high-temperature alloys in their use conditions are not in metallurgical equilibrium. In fact, many alloys gain good high-temperature properties because of their metastable condition. If the material is maintained at high temperature, the tendency is toward a rearrangement of the microstructure in the general direction of equilibrium.

Thus, constituents that are in solid solution frequently tend to precipitate, and in so doing, they may drastically change the properties of the material. Precipitation in the grain boundaries, for instance, can reduce the ductility of the material, particularly in creep loading. This precipitation may occur with or without the application of stresses, but stress and associated inelastic strain tend to hasten the action. Finally, if the material becomes sufficiently embrittled, it may not be able to withstand the small amount of plastic deformation required in a single thermal-stress cycle, and fracture begins.

Corrosion: Another process that may reduce thermal-stress resistance is chemical action. The surface of the material is usually in contact with oxygen or other gases capable of chemical reaction with the material. At the high temperatures involved in thermal-stress testing, oxides or other weak and brittle scales may form. Thermal-stress testing then becomes a test, not of the original material, but of the resulting surface layer. Discontinuities formed at the surface layer, either by cracking of the surface, or by the disintegration of a corroded product, act as a source of stress concentration that induces and propagates further cracks within the body of the material.

In some cases, the corrosion consists, not of the formation of a surface layer, but of a diffusion into the body of the material. Hydrogen, because of its small atomic dimension, readily diffuses into the grain boundaries of many materials, weakening them and rendering them less capable of withstanding thermal-stress cycling. The importance of intergranular attack is indicated by the fact that so many thermal-stress fatigue failures are intergranular in nature.

Hot and Cold Work: Thermal-stress tests also

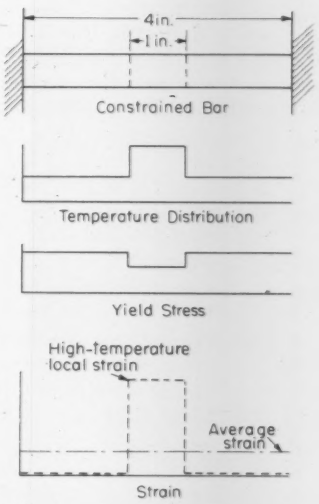

Fig. 18—Localized plastic strain induced by reduced yield point in high-temperature region

embody hot and cold working of the material because of the alternate thermal strains induced. This working is known to have important effects on the strength of material and its subsequent properties.

Grain Growth: One of the effects of working is to cause the material to be susceptible to recrystallization. When grains break up, energy is stored in the slip planes and in the grain boundaries. Upon subsequent heating, there is a tendency for the material to recrystallize to achieve a state of lower stored energy. In many cases, the effect is to cause grain growth. Although there is no clearly defined relation between grain size and resistance to thermal-stress fatigue, materials with large grain size usually have low ductility, which would tend to indicate poorer fatigue characteristics.

Quantitative Analysis

In order to approach the thermal-stress fatigue problem on a somewhat quantitative basis, a parameter must be selected as a basis for interpreting existing data. From the discussion of the idealized model, it would appear that a possible criterion presents itself in the plastic strain per cycle relationship, since it is the plastic strain that ultimately deteriorates the material.

From the more realistic discussion, however, it can be recognized that plastic strain per cycle is a rather hybrid quantity. Part of it occurs at high temperature, part at low temperature. Part of it is of the time-dependent type, part time-independent. As a result, it may involve flow within the slip planes as well as flow within the grain boundaries. These various types of plastic flow may have entirely different effects.

In addition, basing the correlation on strain alone does not introduce in any primary manner the metallurgical effects which are so temperature-dependent. Inducing the strain at one temperature may have an entirely different effect than inducing it at another temperature. Temperature itself could then be the parameter of significance in some metallurgical processes, strain producing a secondary biasing effect. Nevertheless, the correlating parameter that has received the most attention has been plastic strain per cycle.

Plastic Strain per Cycle Theory: It is first necessary to define precisely the meaning of the term, and to indicate how it can be measured experimentally. In the idealized specimen, Fig. 15, no ambiguity exists as to the meaning of the term. Nor is there any problem of definition where the elastic modulus is assumed constant throughout the temperature range involved, Fig. 17*a*, and no creep occurs during the hold period at high temperature. In both cases it is obvious that the plastic strain is

$$\varepsilon_p = \varepsilon_T - \varepsilon_\epsilon = \alpha(\Delta T) - \frac{(\Delta\sigma)}{E} \qquad (10)$$

where $\Delta\sigma$ is the stress range, and E the unchanging elastic modulus (see Nomenclature).

However, when creep occurs during a hold period, Fig. 17*b*, the plastic strain per cycle is not directly related to the total stress range. For the tensile portion of the cycle, the plastic strain $\varepsilon_{t,\,p}$ is

$$\varepsilon_{t,\,p} = \alpha(\Delta T) - \frac{(\Delta\sigma_1)}{E}$$

where $\Delta\sigma_1$ is the stress range developed during the cooling portion of the cycle only. In the heating portion of the cycle, the stress range is larger, thus reducing the direct compressive plastic strain $\varepsilon_{c,\,p}'$. However, the total plastic strain also includes the creep during the hold period. Therefore,

$$\varepsilon_{c,p} = \varepsilon_{c,\,p}' + \varepsilon_{c,\,p}'' = \alpha(\Delta T) - \frac{(\Delta\sigma_2)}{E} +$$

$$\frac{(\Delta\sigma_2) - (\Delta\sigma_1)}{E} = \alpha(\Delta T) - \frac{(\Delta\sigma_1)}{E}$$

Thus, the plastic strain in compression is equal to that in tension, but these strains are not directly related to the total stress range. In the existing literature, the plastic-strain range has been computed primarily through the measurement of stress range, but it is clear that if the total stress range is used, error will result.

An alternate parameter on which thermal-stress fatigue could possibly be based is the area of the hysteresis loop, but as yet no quantitative attempt has been made to correlate data on this basis.

Plastic Strain Measurement Errors Induced by Temperature Variations: Experiments reported to date on thermal-stress fatigue of constrained specimens have all involved considerable nonuniformities of temperature. Extremely large errors can result if the analysis does not account for the tendency of strain to localize in such cases.

In the idealized illustration, Fig. 18, a test section of 1 in. is assumed within a test specimen of 4-in. length. The test section is at a somewhat higher temperature, and therefore lower yield stress, than the remainder of the specimen. The stress-strain curve shown in Fig. 15 is assumed. For clarity, the load free condition is assumed when the specimen is cold. If the specimen is heated to a sufficiently high temperature to involve plastic flow, the stress developed will be the yield stress of the hot portion of the specimen. The cooler 3-in. length of the specimen will have only elastic strain, which is small in comparison to the plastic strain if the temperatures are assumed high enough. The major portion of the expansion of the entire 4-in. length of the specimen will be absorbed in the plastic flow of the 1-in. test portion of the hot section. This is indicated by the strain distribution in Fig. 18.

A limiting condition exists when the temperature of the cooler section is only slightly lower than the hot section, but sufficiently lower to increase the yield stress above that of the hot section. Under this condition, the strain in the hot section will be four times the strain present if the specimen were uniformly heated, or if only the 1-in. hot section were clamped and prevented from expanding.

In practice, strain hardening and elastic strains modify the picture somewhat. But they do not invalidate the general principle that strain tends to be concentrated in the hot sections, and that these strains can be much larger than those computed on the basis of complete constraint of only the hot portion.

The subject of strain localization is important in explaining the difference between low-cycle fatigue tests conducted under varying temperatures and those conducted at constant temperatures.

Failure by Plastic-Strain Cycling

The prior discussion has indicated that if the thermal-stress cycling of a constrained material is between sufficiently wide temperature limits, alternate plastic strain of compression and tension will result. How many cycles of this plastic strain will the material be able to withstand before failure occurs is the question that now arises.

Constant-Temperature Conditions: A first estimate might be that the total amount of plastic flow, not differentiating between tensile or compressive, is equal to the initial ductility of the material. Examination of the limited data available indicates that such an assumption would be grossly in error. It appears that the larger the number of cycles in which the ductility is dissipated, the greater is the total plastic strain. A material, that shows less than 50 per cent ductility in a conventional tensile test, can show as much as 10,000 per cent strain in an alternating stress-fatigue test, if the sum is taken of the tensile and compressive plastic strains without regard for sign. The total plastic strain depends on the strain per cycle as well as the initial ductility of the material.

The first proposal of a relation between plastic strain per cycle and number of cycles to failure was made by Manson[3], based on the work of Liu[4] and co-workers, and is given by the equation,

$$N = \frac{K}{\varepsilon_p{}^n} \qquad (11)$$

The original proposal was that the value of the exponent n (see Nomenclature) should be in the neighborhood of 3. A closer examination of the calculations on which the estimate was based shows that n should be close to 2. Coffin[5] has pointed out that not only is a value of $n = 2$ a good estimate for the results of Liu, *et al*, in which the strain was mechanically applied on aluminum at room temperature, but that this value agrees well with his results on type 347 stainless steel in thermal-stress fatigue. In later reports,[6] he further pursued the validity of Equation 11 using extensive published data on conventional fatigue. Fig. 19 shows one of his analyses of published fatigue data. Since in most cases, conventional fatigue data are presented in terms of the alternating-stress range required to produce failure rather than the plastic-strain range, it was necessary to deduce the plastic-strain range indirectly. According to Equation 11 a plot of N against ε_p on log-log co-ordinates should result in a straight line with a negative slope of $1/n$ or $\frac{1}{2}$.

For several steels such straight lines, Fig. 19, correlate the data[11] very well over the complete range of cycles to failure. Similar correlation was obtained for several aluminum alloys. Even the tensile data point, taken at $N = \frac{1}{4}$ since only one-quarter of the complete plastic-strain cycle is traversed during the unidirectional tensile test, falls on the correlation line. Data in Fig. 19, together with a preponderance of additional documentation by Coffin,[6] attest to Equation 11 as the probable relation between plastic strain and number of cycles to failure at room

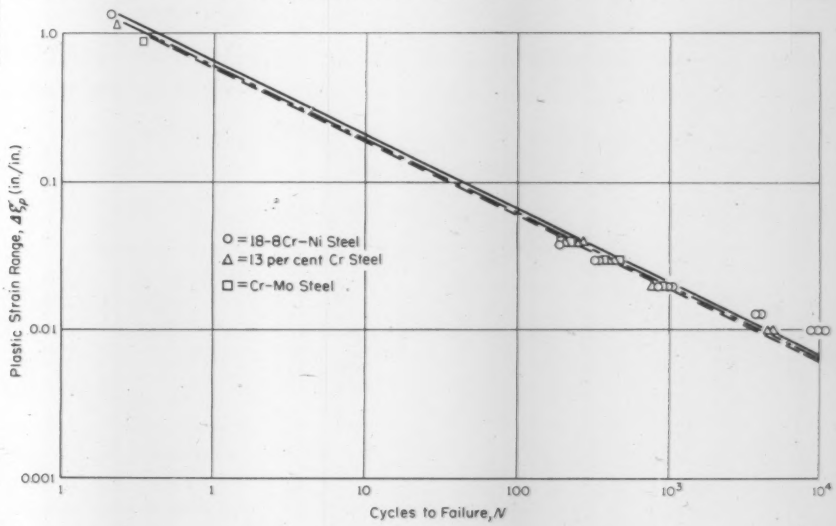

Fig. 19—Conventional fatigue data for several based on cyclic-plastic strain

temperature. The implication that the line passes through the tensile ductility point at $N = 1/4$ could have considerable practical significance because it means that K can be determined without any fatigue testing. This can be obtained by substituting ϵ_f, the fracture ductility, in a tensile test at $N = 1/4$, in Equation 11.

Some research[7] has also been conducted on type 347 stainless steel to determine whether Equation 11 is valid at high temperatures. The solid lines, Fig. 20, show the results for 350, 500, and 600 C. The experimental data agree well with the straight lines of slope $-1/2$ predicted by the equation. Although this investigation served to strengthen the generality of the exponent $n = 2$, some doubt was shed on the validity of the assumption that the equation applies for the tensile test at $N = 1/2$. Thus, it did not appear possible to obtain K accurately from the tensile ductility without some fatigue testing. It is reasonable to expect a difference between the character of the results obtained in a tensile test and those obtained in an alternating strain test. This is especially true in an elevated-temperature test where metallurgical phenomena are likely to occur. The test times involved in a tensile test differ substantially from those of the alternating-strain tests, thus emphasizing any differences due to time-dependent phenomena at high temperature.

Kennedy[8] has also investigated the validity of Equation 11 for Inconel subjected to reversed strain at high temperature of 1300, 1500 and 1600 F, Fig. 21. Although straight lines result when logarithmic plots are made of plastic strain versus number of cycles, indicating the validity of Equation 11, the slopes of these lines indicate value of n between 1.2 and 1.5. Whether this difference results from a strain which is partially of the time-independent type and partially of the creep type, or whether it is due to the temperature or material involved, requires further study.

From limited data thus far available, it would appear that Equation 11 is valid for relating the number of cycles to failure with the plastic strain per cycle if the temperature is maintained constant. The parameters K and n should, however, be regarded as material constants best determined from a few mechanical fatigue tests at elevated temperature.

Changing Temperature Conditions: Whether a relation, in the form of Equation 11, is valid for a thermal-stress fatigue test in which time-dependent phenomena and continuously changing temperatures are present has not yet been completely resolved. Even if the equation is valid, there still remains the question of how the constants relate to those of constant-temperature tests.

A comparison[6] between the effects of plastic strain produced at constant temperature, and at the variable temperature associated with thermal-stress fatigue, is shown by the dotted line, Fig. 20, representing the thermal-fatigue test of type 347 stainless steel thermally cycled between 200 and 500 C, an average temperature of 350 C. At equal values of cyclic-plastic strain, the number of cycles to failure was much less for the thermally cycled specimen than for one mechanically cycled at 350 C, and was less

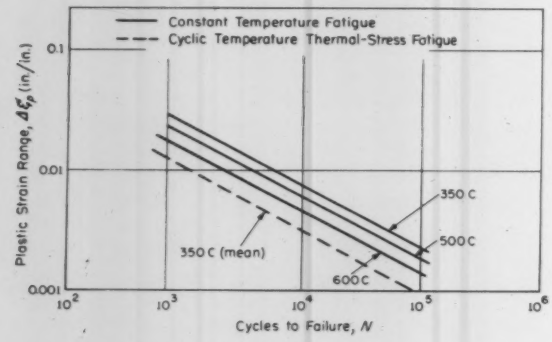

Fig. 20—Cycles to failure in thermal-stress fatigue compared to cycles at constant temperature in similar plastic-strain range

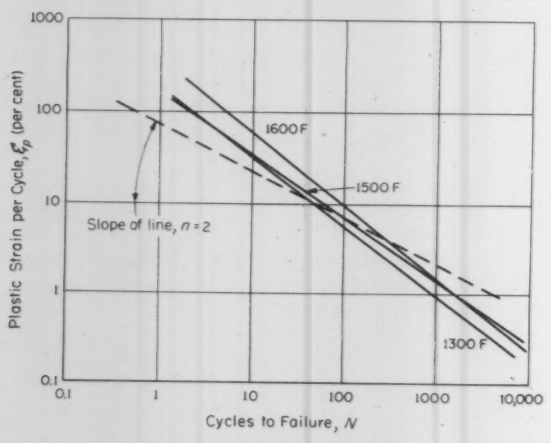

Fig. 21—Strain cycle properties of Inconel rod tested in as-received condition

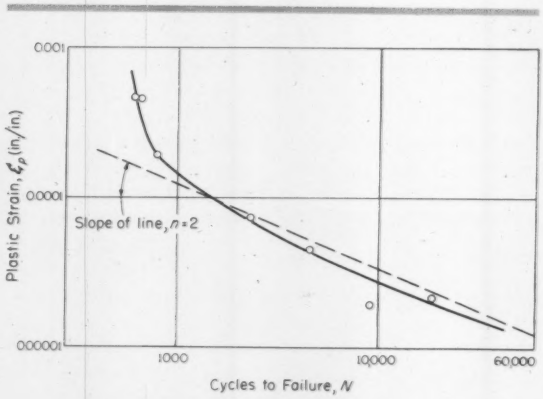

Fig. 22—Variation in cycles to failure of S-816 specimens with average plastic strain per half cycle

than for one mechanically cycled at 600 C, even though no part of the specimen in the 200-500 C thermal-stress fatigue test ever reached 600 C.

One of the most possible significant reasons for this discrepancy is that discussed in the previous section on strain localization. It will be observed, Fig. 20, that the line for thermal-stress fatigue could be brought into coincidence with the line for isothermal low-cycle fatigue tests at 350 C if, at any value of N, the strain is multiplied by a factor of approximately 2.5. As previously discussed, discrepancies in strain as high as this can readily be introduced by strain localization due to nonuniformities of temperature along the specimen.[9] Thus, it is still quite possible that the behavior of a material in thermal fatigue can be predicted from isothermal low-cycle fatigue tests provided the proper strains are used. Whether the isothermal test should be carried out at the average temperature of the thermal-stress fatigue test, or at another effective mean temperature, requires further study. Also, it would appear reasonable to expect differences between a variable-temperature test and an isothermal test at some intermediate temperature if the variable-temperature test involves sufficiently high temperatures to induce metallurgical effects not experienced in the lower constant-temperature test.

When the mean temperature was not maintained constant, and when the maximum temperature was sufficiently high to induce metallurgical effects, the studies by Clauss and Freeman[10] showed that Equation 11 gave relatively poor correlation of the data, Fig. 22, for the precipitation-hardening cobalt-base alloy S-816. Since the number of cycles to failure is plotted on log-log paper against the plastic strain, the plot should be a straight line if Equation 11 is valid. The data points indicated by the circles show the relation between the cyclic-plastic strain and the number of cycles to failure when the minimum temperature of the cycle was maintained constant and the maximum temperature was varied. Thus, the average temperature was increased as the maximum temperature was increased. Also, the maximum temperature was carried into a sufficiently high range to induce metallurgical effects such as aging. It is seen that the curve deviates considerably from linearity at the lower values of cycles to failure due to these effects. Similar but more limited tests on the nickel-base alloy Inconel 550 showed a lesser trend toward nonlinearity in the same temperature range. Since Inconel 550, also a precipitation-hardening material, shows a lesser tendency to harden further, or to over-age in the times involved in the tests, it can be concluded that a major reason for the failure of Equation 11 for S-816 is the metallurgical factor associated with the high temperatures.

The next article of this series will cover the factors affecting thermal-stress fatigue of ductile materials.

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This article is the third in a series by S. S. Manson on thermal stress in design. The previous articles and the issues of Machine Design in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials"... June 26, 1958

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11. A. Johansson—"Colloquium on Fatigue," 1955.

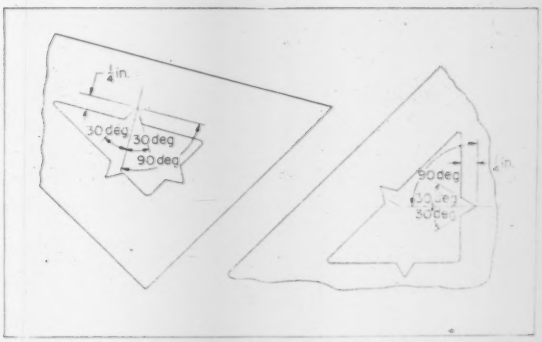
Tips and Techniques

Center Reinforcement

Clear nail polish, applied to tracing paper or cloth, will strengthen a center that is to be used to swing many arcs or circles. Lay out the center lines and dab on a small amount of polish with the applicator brush.—M. L. Forrester, *Melbourne, Fla.*

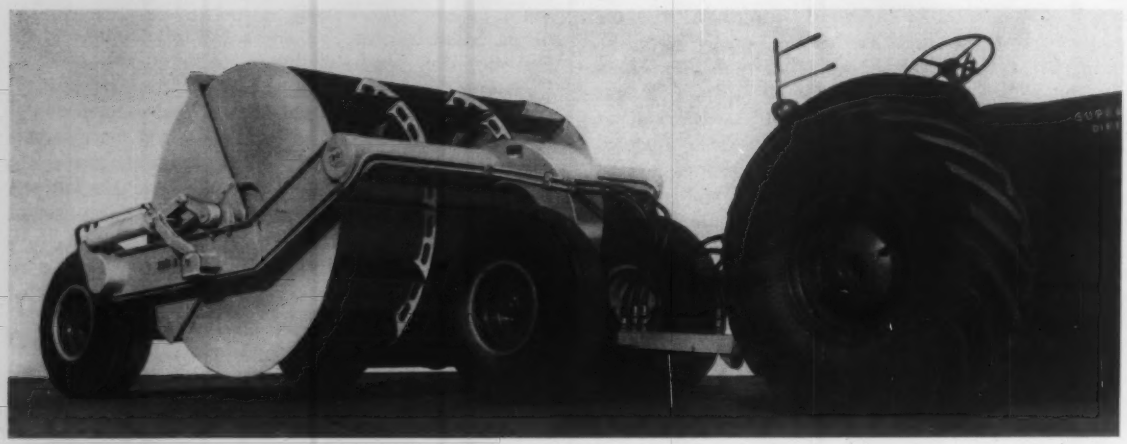
Drawing Finish Marks

To save time when applying conventional finish marks, notch a 60-degree "Vee" on the inside faces of triangles. The V-notches can be scribed on the triangles and then carved out with a pocket knife. The carved notches can be smoothed with a fine file or sandpaper. Using such a triangle eliminates



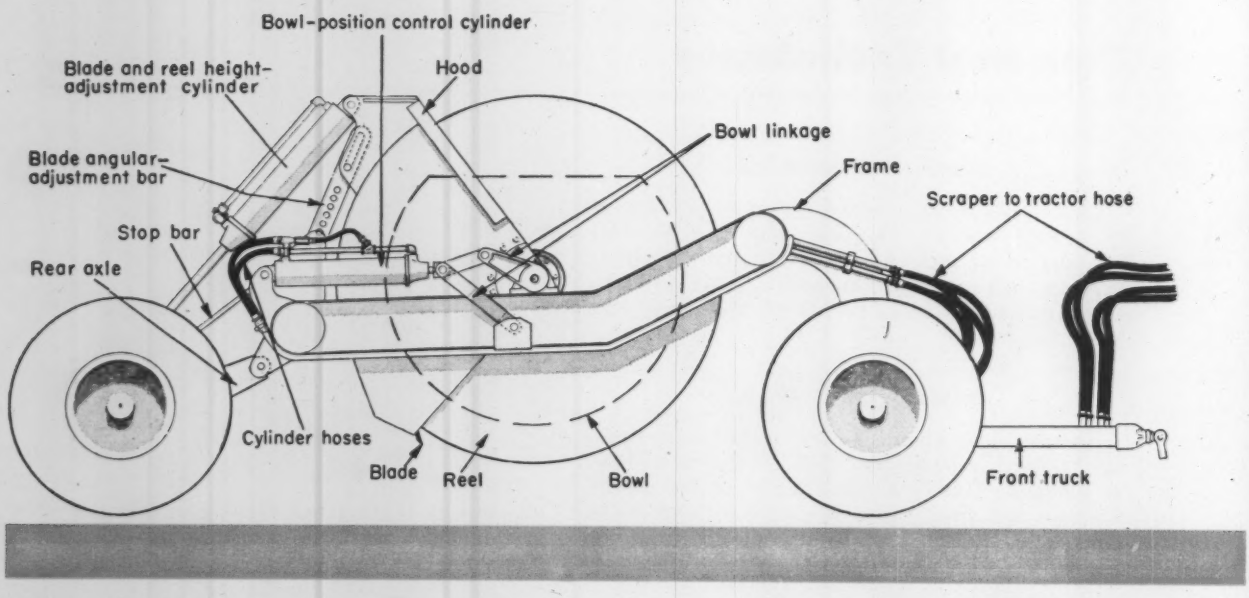
unnecessary turning and flipping of triangles when making finish marks on any drawing.—Gerald A. Nikastro, *Cleveland, Ohio.*

Reel with Knife-Edge Blades

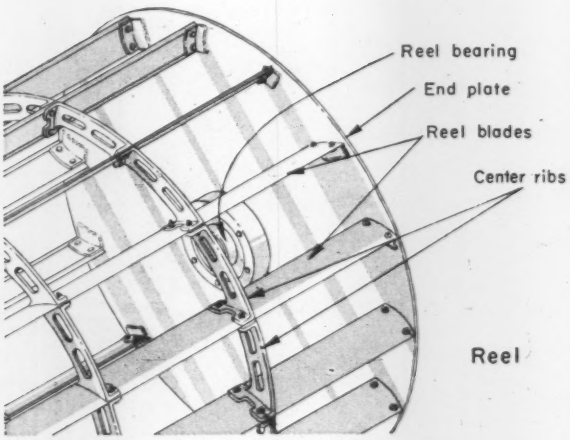


BOTH CUTTING AND LOADING of earth is produced by a reel of novel design applied in a new self-loading hauler-scraper. Heavy-duty blades on the reel cut into the earth in a plane normal to cutting plane of the scraper blade beneath. Earth is cut off and pushed along by the reel blades in a rotary direction between the hood and the bowl, both of which are normally held stationary. When the material reaches the open portion of the bowl, it falls out of spaces between reel blades into the bowl.

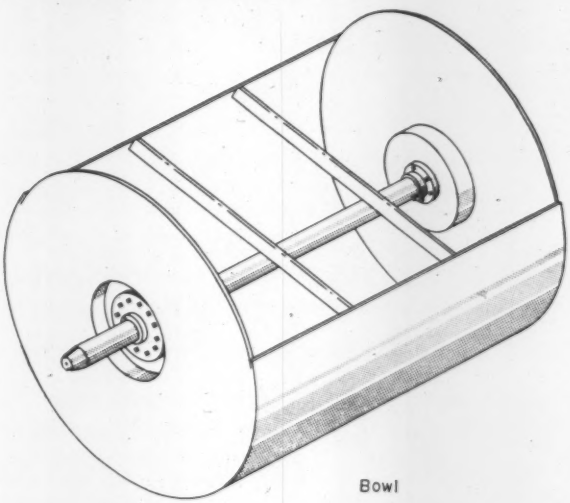
Built by Ge-Be Mfg. Co., Gilroy, Calif., the unusual design minimizes dirt pile-up ahead and ground friction. The Rotohaul scraper is designed to carry 6½ cubic yards of earth. It loads soil which is sandy and loose or hard and tough.



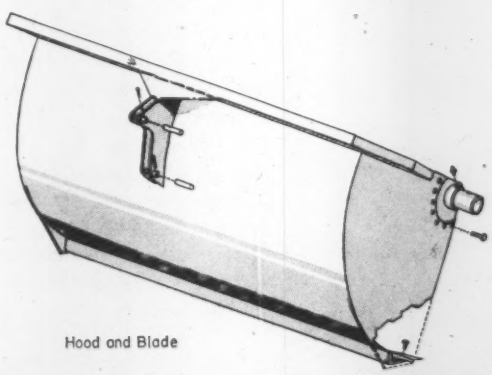
Provides Rotary Loading Action



Reel



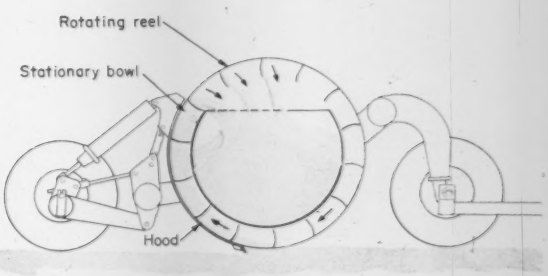
Bowl



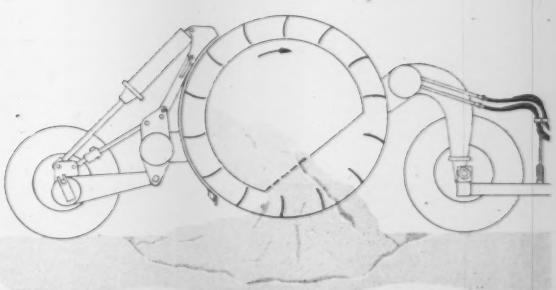
Hood and Blade

DEPTH ADJUSTMENT of scraper blade and reel during loading, dumping, and spreading is hydraulically controlled by a hydraulic ram cylinder in center back. Angular position of the hood and scraper blade assembly is manually changed with an adjustment bar.

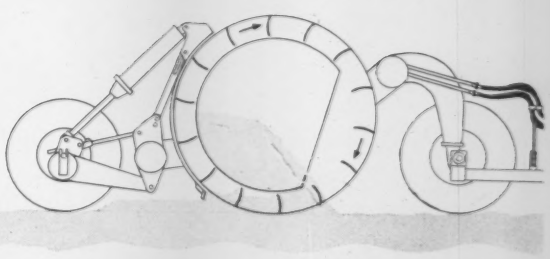
The bowl is turned over for unloading and spreading with a second hydraulic ram cylinder.



Loading



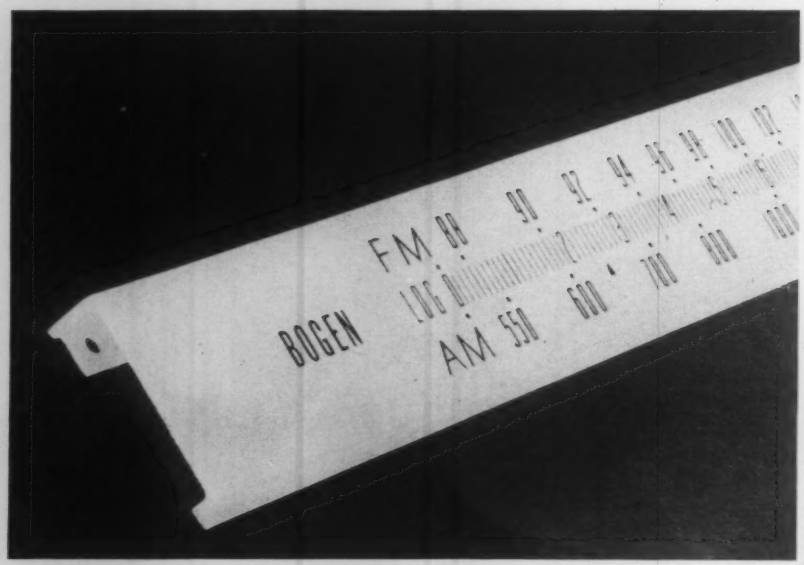
Dumping



Spreading

Dial Scale Intregral Part of Electronic Cabinet Enclosure

HIGHLY STYLIZED APPEARANCE plus a functional design are achieved by industrial designer, Arden Farey, in a new David Bogen Co. AM-FM amplifier-tuner. The outstanding feature of the design is the simple but effective integration of the dial scale into the cabinet enclosure.



EXTRUDED DIAL SCALE on amplifier-tuner is made of Plexiglas and produced by Anchor Plastics Co. Inc., Long Island City, N. Y., as reported by Robert Marx. The lower part of the cabinet front is completed by an anodized aluminum extrusion which interlocks with the plastic extrusion.

Station-setting indication is made by a subtle line of light produced by a movable light source located behind the dial scale.

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PART 1
FLAT
STAMPINGS

PART 2
FORMED
STAMPINGS

A practical manual for

Stamping Design

This is the conclusion of a comprehensive guide for design of sheet-metal stampings. Emphasis is on what is and what is not economically feasible—to indicate the shapes, sizes, tolerances, and finishes that can be achieved without high cost. Part one covered materials, blank design, pierced and slotted holes, and similar features of flat stampings. In part two, the author begins with a discussion of formed and bent parts.

THE sharpness of inside bend radii is usually a minimum of 1*t* for soft metal and 2 to 3*t* for stiffer metals. Sharper bends take additional operations. Metal pushed around a radius tends to spring back even if the bend is set by making the radius of the outside a bit larger than the inside radius plus *t*. Stainless steels, titanium, heat-treated aluminum, and medium-carbon steels require larger radii and tend to show considerable springback. With them it is hard to hold a 1-deg angular tolerance, while ½ deg is good commercial practice on most softer metals.

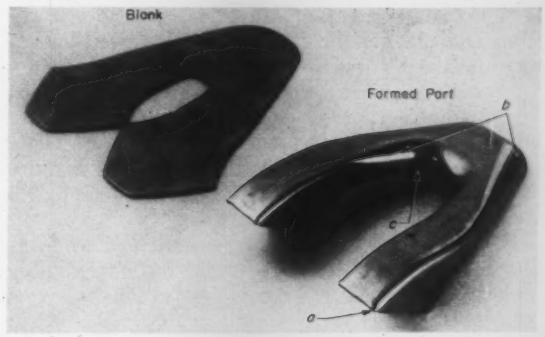
On the radius, the inside surface of the metal is under compression and tends to spread a little, Fig. 1. It is one reason why heavy folded up boxes or machine bases are seldom used. This can be helped by: 1. Larger radius. 2. Notching out the bent portion. 3. Confining the metal at the bend. 4. Shaving after bending. The notched out edges of medium materials can be right-angle folded fairly tight, with not over 0.005-in. gap, but with some scratching as metal is moved.

Shape of the part may permit using intermediate tempers of low-carbon steel, brass, or particularly aluminum. These call for easier radii, and grain direction should be designated so that forming runs across the grain because forming parallel to the grain is likely to cause cracking. Intermediate-temper steel is not readily available, so if only a few hundred pounds are needed, deviations from the material designation may be necessary.

Lance Forming: Tabs and legs are frequently punched out of the parent metal by a punch that cuts and bends in one operation. These tabs are useful for positioning or for staking, twisting, or folding back over an adjoining surface to act as a fastener. The knockouts in junction boxes are first lance formed, then pushed back into place.

If a tab is of smaller size than the hole it comes from (it cannot be bigger) the hole is punched before the tab is bent. If the tab-bend radius starts

Fig. 1—Heavy flanged part illustrates spreading of metal at end of bend, *a*, and increased flange radius around a curved portion, *b*. The increased flange radius was necessary to prevent splitting at point *c*.



inside the hole edge, there is no problem, but if the plane of the tab should be even with the hole edge, small relieving notches should be used on both sides of the tab, Fig. 2. If notches are not indicated by the designer, the stamper assumes there is no objection to torn metal beside the tab. Similar relieving notches are a guarantee against tearing in folding up bases or panels.

Any tab, or folded edge, should be at least $3t$ long to give bearing for the punch. Even on this length, short tabs require more angular tolerance than longer ones. If designed shorter than $3t$, a longer tab is formed and then trimmed, at extra expense.

Often a part of the stamping is lance formed with both ends remaining attached to the parent metal. Such bridges formed out, in, or alternately, locate and hold round pins and other parts accurately and inexpensively. Occasionally, alternate-bridge designs are tapped. The stretching action is quite severe; even though a portion of the metal comes from the uncut sides of the bridge, about 25 per cent of increase in original metal length is maximum, a little more with soft metal, some 10 per cent less with stiff metals. Thus, 0.5 in. of original metal can be stretched out to 0.625; to form a full half round would call for 0.785 in. or almost 50 per cent stretch. A half round requires about 4 radius lengths of lance forming with the ends easing into the parent metal, Fig. 3. When all four sides are left attached, an increase in length of 15 to 20 per cent, depending on temper and stiffness, is maximum for one operation.

If tab heights, or bridge heights, are interrelated in use, a note to this effect is called for. Such surfaces that mate adjacent parts are sometimes cross-hatched on the outside, a practice that is very helpful, Fig. 4. Also, to plan gaging, holes in tabs and locations which go together should be covered by notes.

Strengthening Means

Frequently, more stiffness than is inherent in light sheet stock is called for in one or more directions. Consequently, embossing after forming, such as putting in a trade-mark, is used to make the part more rigid; sometimes pre-embossed metal is used. Embossing is also a way of eliminating small extra amounts of metal in drawn panels and in sides and bottoms of drawn boxes that give an oil-can effect, Fig. 5. Corrugation is a well-known way to make metal more rigid.

Strengthening ribs that are strategically located will strengthen lightweight surfaces. The ribs may be flat-bottom, round-bottom, or V-shaped. If a rib is embossed across a bend radius, the rigidity of bend is notably increased; the rib acts like a gusset in welded construction.

Formed shapes can also be strengthened by hemming, by folding the edge up in a flange, or by curling, Fig. 6. This presents few problems except for curved edges, but corners are impossible. When

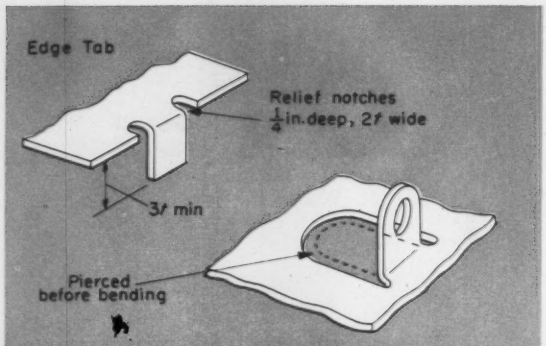


Fig. 2—Design of tabs or lanced areas requires relief notches to avoid tears

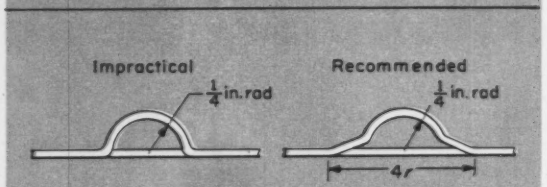


Fig. 3—Lanced bridge at left requires too much metal elongation. Blended design at right is practical

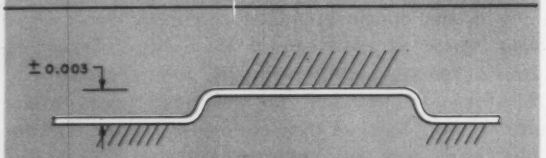


Fig. 4—Cross hatching to indicate functional surfaces is helpful to stamper when planning gaging requirements

Fig. 5—Embossed ribs were added to flanged part to eliminate oil-can effect caused by drawing flange on a concave corner

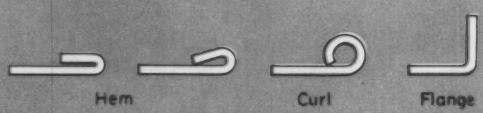


Fig. 6—Common methods of reinforcing edges or providing smooth surfaces

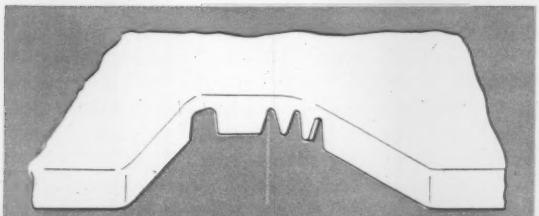


Fig. 7—Reduction or notching of flange on a concave radius helps eliminate wrinkles but weakens part

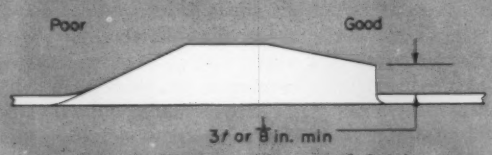


Fig. 8—Flanges with tapered height should stop at 3t minimum height

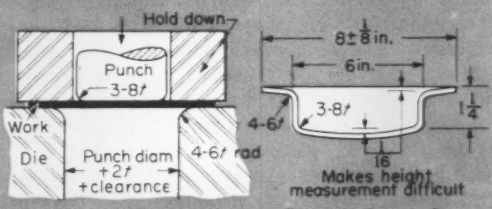


Fig. 9 — Drawn cup, die, and flange - trimming die show practical single-draw cup and how it is made

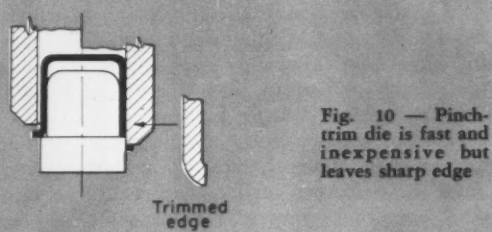


Fig. 10 — Pinch-trim die is fast and inexpensive but leaves sharp edge

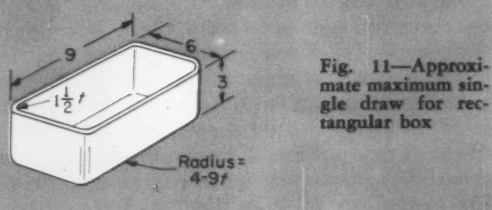


Fig. 11—Approximate maximum single draw for rectangular box

a flange is on a concave radius, the material is severely stretched. Increase in flange width or sharpness of the curve increases the severity; even if cracking is avoided, flange depth is reduced as metal is pulled up. When the flange is on a convex radius, the metal is compressed and tends to wrinkle. Notching the flange relieves the problem but weakens the support. Sometimes a notch part way into a flange or hem is good design, Fig. 7. An increase in the flange radius along the curve is also of assistance, Fig. 1. Minor wrinkling on the inside radius can be wiped out in forming, but there may be some scratching. If flanges must follow curves, the curve should have maximum radii and the flange have minimum height. If flange height is tapered it should not go below $3t$ (or $\frac{1}{8}$ in. min) in height, Fig. 8.

Curls can be inside, outside, or with an extra operation, centered. They are not expensive. Suggested inside diameters run between 3 and $8t$. A minimum corner radius of $20t$ for a curled edge is good practice. The lower side of the curl may run a bit flat. If a curled tab must be round, an extra operation is required and the designer should so note.

Deep-Drawn Parts

Drawn parts include cups and shells, sleeves and short tubular shapes where tolerances are too tight for tubing, boxes, cans, refrigerator trays, fenders, typewriter sides, and a host of varying shapes. The shallow parts are drawn just once but deeper parts like eyelets, cartridge cases, filter cases, and cones are deep drawn and may involve several successive draws, each smaller in diameter than the preceding. Drawn parts may require intermediate annealing to restore ductile grain structure for further working. Good design calls for as few operations as possible to achieve the desired result, and this involves measuring depth of draw. The usual standard is the ratio between blank size and mean diameter of the finished cup—or on a flanged cup, the cup that would result if the flange were drawn into cup form. The presence of tabs, flanges, re-entrant curves, bosses and irregularities introduces other variants greatly affecting the severity of metal working during drawing.

A round cup is cheapest to tool and work of all drawn shapes. As an example, consider a cup 6 in. in diam and $2\frac{3}{4}$ in. high before trimming, made from a 10-in. circle, Fig. 9. The central 6 in. lie against the punch face, largely unworked, but as the punch descends, the periphery of this center near the punch radius is strained as it pulls the metal after it over the die radius. The 31.4-in. blank circumference is brought down to punch diameter, or to a circumference of about 18 in. It thickens only slightly and, except for very heavy stock, has to be restrained by a hold-down or pressure pad to prevent wrinkling and tearing. Probably the cup rim will have four "ears," with and at right angles to the grain direction of the original material un-

less "nonearing" stock is specified.

The metal will thin 2 or 3 per cent around the punch radius and thicken about 0.10*t* at the open end. The same blank would give a 6-in. cup 1¼ in. deep with a 1-in. flange all around, or with a tab extending to that length. A cup-bottom radius of less than 3*t*, or a flange radius of less than 4*t*, must be reshaped in a succeeding operation. If a mating part requires 90 deg between cup wall and flange, consider grooving the flange, preferably with a relieving radius on the flange face.

For a symmetrical shape with an end area of under 12 sq in. and 6 to 8 times as deep, consider impact extrusions of aluminum, zinc, or copper.

Drawn-Cup Tolerances: An OD tolerance on a drawn cup is considered met when the average of any two micrometer readings, taken at right angles, falls within the limits. In other words, out-of-round is not covered since precise roundness is very hard to get. Concentricity of ID and OD will be as it comes; it can be held to about 0.05*t* if desired. If the bottom is pierced out to make a sleeve of the cup, out-of-round and concentricity may be important. Piercing the bottom increases the out-of-roundness by releasing strains, so a stress-relief anneal before piercing may be required.

If a print calls for a uniform OD with tight tolerances from top to bottom, tight die clearances with an ironing action are needed to overcome the thickening tendency. It is best not to call for such clearances that require constant watching, repair, and inspection unless vital to part use.

To select an economical tolerance, consider the 6-in. OD cup with a ±0.002-in. tolerance on the diameter. To strip the cup from the punch, the punch will be tapered from 0.0005 to 0.001 in. per inch of height. This uses almost 0.003 of the 0.004-in. tolerance spread. Probably sheet steel would be used. Strip for a blank 0.093-in. thick has a tolerance of ±0.006 hot rolled, and a crown tolerance of +0.004. If slit sheet is used, the tolerance is ±0.007 in. Using cold-rolled material at ½ cent extra per pound for sheet (but 1.9 cents for strip) would reduce these tolerances to ±0.003, +0.0025 crown. Between material tolerance, punch taper, and certainty of die wear (unless carbide inserts will be justified on the quantities needed), it is apparent that a ±0.002 tolerance is very tight. The stamper would probably ask for ±0.010 in. minimum tolerance, or ±0.003 if sizing is added.

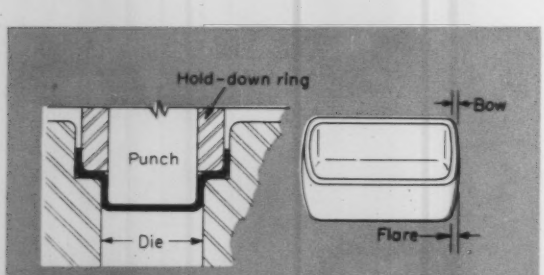


Fig. 12—Two-draw square boxes are drawn from round cups to provide room for entry of hold down. Material memory causes bow and flare in box walls.

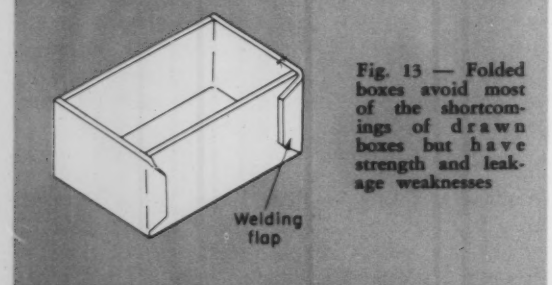


Fig. 13 — Folded boxes avoid most of the shortcomings of drawn boxes but have strength and leakage weaknesses

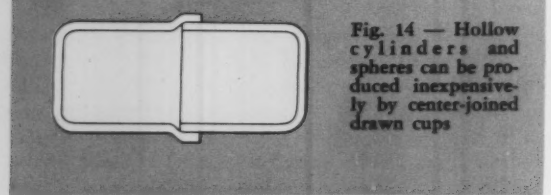


Fig. 14 — Hollow cylinders and spheres can be produced inexpensively by center-joined drawn cups

Trimming: The cup may well have to be trimmed. Even with nonearing material, gage variations find their way up the wall, and ±2 per cent of cup height is about the minimum allowance without trimming. A trimming machine with cut-off roll can trim height to within ±0.010 in. The cup might be rotated on a horn press and trimmed in three bites, or accurately trimmed in a lathe with perhaps deburr and chamfer on the same set-up. The cup could be drawn with a very small flange and pinch trimmed in a press—the least costly method, Fig. 10. Pinch trimming is used mostly on material less than 0.050-in. thick. A ring on the draw punch does the trimming; it is fastest and cheapest but leaves a sharp feather edge.

If a flange is left, it should be trimmed, similar to a blanking operation. However, if the burr is wanted under the flange, the cup has to be trimmed from the direction of the open end. The flange would then have to project at least ⅛ in. beyond the 4*t* flange radius so that the tool around the cup body is thick enough to stand up, Fig. 9.

Because of entrapped air and lubricants, the bottom of a 6-in. diam drawn cup will probably be at least 1/16 in. out-of-flat, and would require a striking operation to correct. Unless indicated, burrs are not removed, and the lubricant is left on, which provides some protection during storage.

Maximum Draws: A 6-in. cup 2¾ in. deep is a deep draw for one operation. There is a 40 per cent reduction of blank diameter to cup. Ratio of depth to diameter is about 45 per cent, a fair ratio. Red brass, stainless type 305, aluminum 1100, 3003, or 6061 could go a little deeper, or steel if a center hole were pierced. Copper or Inconel would thin at the punch radius. The same cup with a redraw could go to 4 in. diam and 5¼ in. deep before trimming (60 per cent reduction, 1.31 ratio

of depth to diam). Between 5 and 7½ per cent of cup height is standard allowance for trimming. An intermediate anneal would be needed before further working were undertaken. A depth six times the diameter calls for four draws and one intermediate anneal; the cup ends up hard. During redraws, punch radii may work down to 2*t*.

Rectangular Boxes: Drawing square or rectangular boxes introduces different considerations. Frequently, rectangular boxes start as round cups. The number of operations is controlled as much by the corner radii specified as by the depth of draw. The bottom radius should be between 4 and 9*t*, Fig. 11. There is some flow of material from the sides to the corners, so the action is rather like drawing a cup with 50 per cent more radius than the corner radius. A box with 1-in. radius corners, 5 in. deep takes as many operations as a 3-in. diam cup 5 in. deep. Depth, of course, does control blank sizes.

Large redrawn boxes of light to medium-thickness metal present many problems. A spring hold-down, or double-action press cam, is frequently essential. If the shape cannot be achieved in one draw, it is necessary to work from a rounded shape to let the hold-down in. The metal has memory, and the sides tend to bow out, Fig. 12. Further, due to drawing over die radii and suction during stripping from the punch, the sides tend to flare in at the bottom and out at the top. There are three ways to improve this, none too satisfactory: Slight ironing to set the metal, embossing to pick up any excess, and the man with the hammer. A straightedge test revealing 1/16-in. vertical concavity or 3/32-in. outward horizontal bow indicates good job. Medium-gage metals set better than light gages.

Flanged Boxes: Rules for flanged boxes reflect many variations. Flanged boxes are "tough jobs" unless shallow enough and have large enough corner radii to make in one draw with perhaps a strike to flatten the bottom and the flange. Operations resemble those for straight-sided boxes if the flange were wiped up. A flange does reduce bow.

Folded-up boxes and panels have certain advantages over drawn boxes in that tooling is less costly. Even on deep shapes, square corners and sharp bottom radii can be provided. The sides are straighter, both horizontally and vertically. Most drawn boxes over ½ in. deep have to be trimmed; folded boxes do not. The drawn box, of course, is stronger and has no corner joints to leak. The ends of a folded box can overlap slightly inward to provide good construction for spot welding, Fig. 13.

Hemispheres are drawn in one operation with oversize flanges. If the flange is not wanted, it is trimmed off, or it may be trimmed and wiped up with an offset to take a mating hemisphere and make a hollow sphere.

In designing closed containers, tools and production may well be less costly if two mating cups are drawn, one with an offset or both with small flanges, and brazed or welded together rather than drawing a cylinder and cover, Fig. 14. Two of the example cups would give a 4-in. cylinder almost 10-in. high, while a 9-in. deep shell would require three draws, an anneal, and separate cover tools.

Flanged-Cup Shapes: The rules for cups with flanges apply to flanged sleeves, extruded holes, and bosses too deep to make in one operation. The necessary stock either comes from the hole or it has to come from the outside, so a large flat part may require a number of operations to gather enough material for a deep boss, Fig. 15. A wide, shallow cup is drawn first. Then, the outer portions of the cup are pushed back flat, leaving a smaller-diameter central cup. The boss depth is not important except as it increases the needed blank diameter. The boss diameter is more important, since a large boss diameter will require fewer repetitions of this process than a small one. Concentric rings on the flat, a few thousandths thinner than original-metal thickness, remain to indicate where the earlier radii fell.

Other irregular drawn shapes also require gathering metal and development operations. These include re-entrant curves and cup bottoms with bosses. If these cannot be stretched without thinning and cracking, or pulled from the circumferences of holes, there is little the designer can do to secure these shapes inexpensively except to permit all working from one direction rather than two or three and to keep radii generous (4*t* min) so

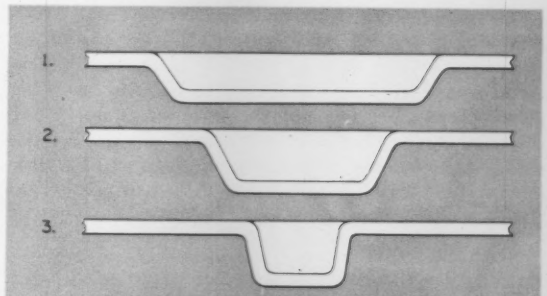


Fig. 15—Small-diameter bosses require multiple draws to gather sufficient material from surrounding sheet

Fig. 16—Taper-drawn cup of aluminum foil shows exaggerated but typical wrinkle problems on side walls

Photo, courtesy Kaiser Aluminum

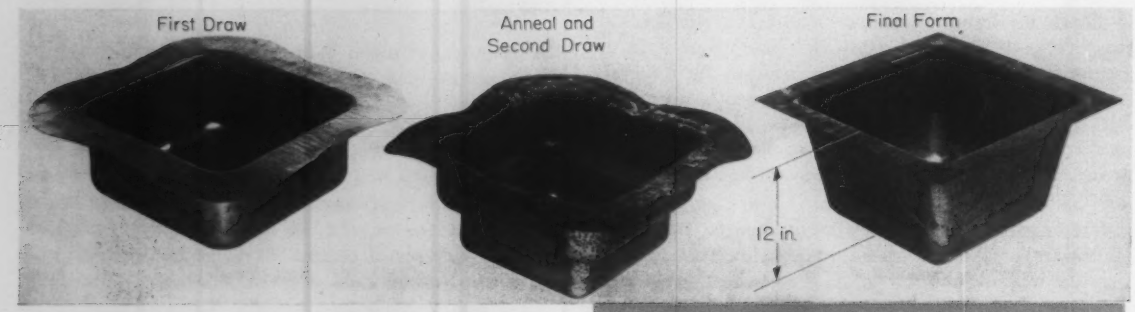


Fig. 17—Rectangular dome must be step drawn and then struck out to produce tapered walls without wrinkles

the metal will flow where it is wanted. If metal tolerances lead to excess metal, embossing may tighten up the part.

Tapered Cups: Another difficult task is to make unsupported metal follow any rules. As a result, parts with bottom radii over $8t$, tapered boxes, and cones challenge tool designers, Fig. 16. The punch must fit the bottom shape, but the supporting die is out where the top of the part is drawn; the blank lies across unsupported. The only way to avoid side wrinkles is to make the first operation about the size of the top with generous radii. The part is then redrawn to the required bottom diameter, giving in the case of a truncated cone, an intermediate-draw shape of a straight-walled cup with two or more basic diameters, Fig. 17.

Aside from simple round cups, drawing requires considerable metal movement in tension and compression, stretching and pulling. This leads to an exception to the general rule of using the lightest metal possible. For small parts 0.025 in. is minimum material thickness, for medium parts 0.031 to 0.040 in., and for large parts 0.062 in. Admittedly, auto fenders run below these gages, but this is one reason why the finest stamping experts in the country have troubles with them.

Necks and Bulges

When dealing with a cup having a top smaller than the body, such as an electric coffee maker, smooth curves may be spun on a lathe. Necking in a press costs less. Repeated necking operations can bring the open end of a shell down to a gas-tight joint, as in small CO_2 cylinders. The top of a cup, if material is not too light, may be reduced about 20 per cent of its diameter in one operation. Below the reduced diameter an angle roughly 30 deg blends out to the larger diameter with a radius of about $2t$ at the junctions. The angle of this step may be separately struck later.

There are also cases where diameters larger than basic are called for. Using water, rubber, or a segmented internal-die post, punch pressure may be transferred radially to the walls of cups, up to stretching limits. Since a split die is often used, the operation is slow.

An interesting variant of bulging permits a flanged or open-end cup to have a flange lower down the side wall, or even at the bottom, Fig. 18. The flange is slightly less than double the wall thickness. The process is not expensive and may save considerable machining. The OD tolerance of a 3-in. flange is ±0.008 in.; it may extend 25 to 30 per cent beyond cup diameter.

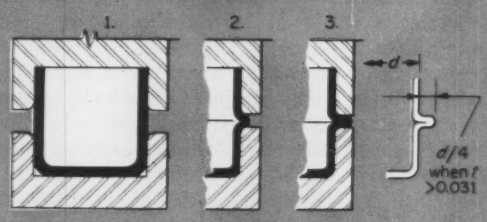


Fig. 18—Bulging operations can produce flanges at any location on cup wall

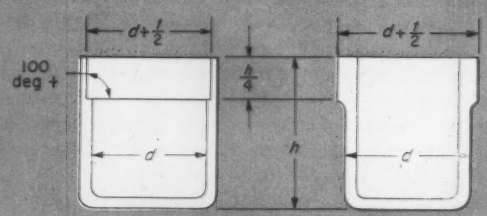


Fig. 19—Either thickening or thinning of cup walls can be produced, usually for about 25 per cent of cup height

Alteration of Thickness

Stampings are essentially of uniform thickness, but since metal is plastic, stampers have evolved a number of ways to alter stock thickness by applying pressure. Most common is ironing a cup wall between the punch and die with the clearance less than original stock thickness. This can produce a cup with straight sides or a heavy bottom and thin walls. After one operation, the wall can be 20 to 40 per cent lighter, depending on the metal

and its degree of softness. Lead, chromium-stainless steels, and titanium will not iron well. Using cartridge brass for cases, several ironings and anneals can bring the wall down to 10 per cent of the base thickness. Then the heavy base receives a swaging or heading operation, squeezing solid metal out sideways to form the familiar extraction flange because it has no other place to go.

The outside of a cup wall may have two thicknesses with a reduction of up to 0.25t. With heavy metal, a stepped punch can give a larger ID at the open end, including a seat of 0.25t width, Fig. 19. Also, cup tops may be thickened down for 25 per cent of the cup height by upsetting.

Interest in the swaging, coining, and cold-heading processes is high because of their inherent economy. A soft slice of 2-in. bar steel squeezes down to 60 per cent of starting height, producing a smooth-edge pancake with edge cracks just beginning to show. Diamond knurls are coined into steel gun-butt plates. Small parts may be swaged around bosses, leaving these parts projecting from otherwise flat stampings.

Coining: The derivation of the expression "coining" is obvious—its uses multiple. Very precise tolerances can be held. However, because of pressure requirements, in steel the coined area rarely extends over a total of more than 4 sq in. Copper and aluminum take a third less pressure. Coining works best when metal has some place to go, since metal is not compressible and extra causes flash.

Cup tops can be made round by coining faster than by machining. Gear and sprocket blanks can have thinned teeth, and blanks can have stepped peripheries. Small webs may be coined thin, with slanting walls, down to 0.25t, and with only slight build up around the edges.

Another use for coining is functional grooving of heavy material to avoid end milling. For instance, a slot $\frac{1}{8}$-in. deep with fairly sharp corners, in $\frac{1}{4}$-in. stock, can be coined with some projection or relief on the die side of the part, Fig. 20. Shallow oil tracks on flat surfaces are easy to coin. For constant depth, a medium-size part must be brought to a close degree of flatness before coining.

Coining names, instruction, scales, and trademarks is common. The stamp should not penetrate more than 0.2t; for stiff metals, 0.12 t max. The die side has a somewhat burnished appearance after deep stamping. Raised letters are unusual unless embossed from behind.

Dowel buttons and bosses of pushed out metal are frequently used to locate parts for welding or assembly, Fig. 21. One common form calls for a slightly rounded punch with a diameter 2t greater than desired button diameter. Button height should not extend more than half the button diameter. For greater button heights, up to full button diameter or more than t, a punch of slightly less diameter than the button but with an angle and point half this diameter, is forced into the stock. Welding projections or rings are frequently forced out in this fashion, with a larger or smaller punch forming on the back without shearing the metal.

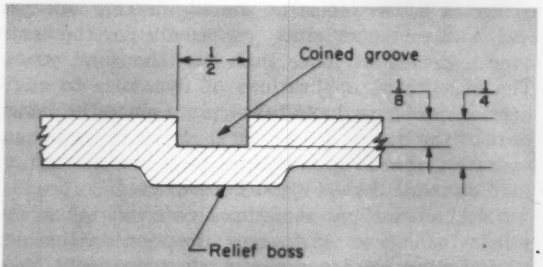


Fig. 20—Grooves with quite sharp corners can be coined into heavy material if a relief boss is permitted

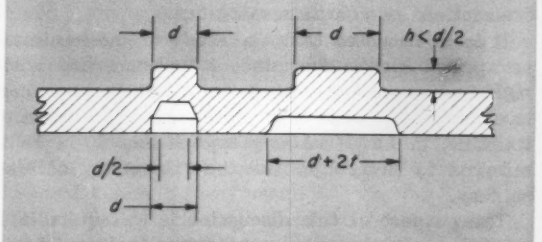


Fig. 21—Dowel bosses or buttons can be coined up to a height of more than original stock thickness

EDITOR'S NOTE

This article is another in MACHINE DESIGN's continuing coverage of sheet-metal stamping design, written and prepared by acknowledged authorities in the field. Recent articles in the group have considered various aspects of stamping design and applications for stamped parts.

"Strengthening Metal Stampings," Nov. 1, 1956—This article treats in considerable detail the subject of ribs, corrugations, flanges, curls, and other strengthening means. Costs can be maintained at the lowest possible level by judicial use of light-gage metal and devices to provide rigidity.

"Hydroforming," June 27, 1957—A relatively new process that is ideal for low-cost forming of complex drawn shapes. Hydroforming has become very popular in the aviation industry. This article tells how the designer who requires low quantities or complex shapes can secure new freedom from the cost and design limitations for conventional drawn parts.

"Stamped Gears," Dec. 12, 1957—Stamped gears offer numerous cost advantages for light-duty, high-production gearing. The article is a comprehensive presentation of the subject, telling where to use stamped gears, how to design them, and how to employ stamped design for unusual applications such as bevel gears, wide tooth-face gears, gear blanks for later machining, and similar uses.

"Designing Low-Cost Stampings," Apr. 3, 1958—Focused on the cost factor, this article presents 14 areas in which the designer may be able to reduce his stamping costs. Written by Harold Daschner, managing director of the Pressed Metal Institute, the material in this article is based upon the accumulated experience of many stamping firms.

Additional articles in the future will treat more of the detail areas of stamping design and application.

ANTICIPATING DYNAMIC BEHAVIOR

The kinematic consequences of linkage deflection and vibration, loose pivots, and similar "realities" of mechanism design are hard to see on paper. This article examines such dynamic effects, shows how they bring about departures from strictly geometrical behavior, and suggests remedies.

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AT THE First Conference on Mechanisms (1953), it was pointed out that increased attention to the design of mechanisms stemmed from two sources: 1. The need for better performance at high operating speeds. 2. The increased importance of automatic computing and control equipment. Trends that were noted then have continued. We now observe an ever-growing attention to the dynamics of machinery in its broadest sense, an attention that goes beyond those considerations which are of strictly kinematic nature. A definition of terms may show why.

Rigid-body mechanics is usually subdivided into *statics* and *dynamics*. Statics deals with force distribution in bodies at rest; dynamics treats of the relationships of forces and motions. When it becomes necessary to take account of the small deformations that actually occur in machine parts, the topic is treated in that branch of mechanics known as strength of materials and in the theory of elasticity.

The subject of dynamics is subdivided into *kinematics* and *kinetics*. Kinematics deals with the description of motion of bodies without reference to the causes of the motion; kinetics is concerned with finding the nature of the motion of bodies under the influence of given forces, or in finding forces needed to produce motion.

[1]References are tabulated at end of article.

Statics is the oldest of the engineering sciences and, in its present state, represents developments over a period of more than two thousand years. The significant applications of dynamics to engineering problems have taken place since the latter part of the nineteenth century. Prior to that time, operating speeds of machines were low enough so that dynamic forces could be neglected.

"Mechanisms" is sometimes referred to as applied kinematics. It focuses attention on the motion problem and assumes that components have sufficient strength and rigidity. As an area of study in engineering, it appears to originate with the writings of Franz Reuleaux in 1875.[1] Reuleaux emphasized the need to analyze basic elements common to various machines, rather than independent descriptions of complete machines.

It is to be noted that the study of mechanisms, or applied kinematics, since it is concerned with rigid bodies moving with definite relative motions, is essentially a branch of mathematics. Professor Rankine, in his *Machinery and Millwork,* in 1869 referred to the subject as the "Geometry of Machinery."

The purpose of this discussion is to inquire into conditions which cause a mechanism to depart from its intended geometrical behavior. Many modern applications require analyses based broadly on dynamics, rather than simply on kinematics. The

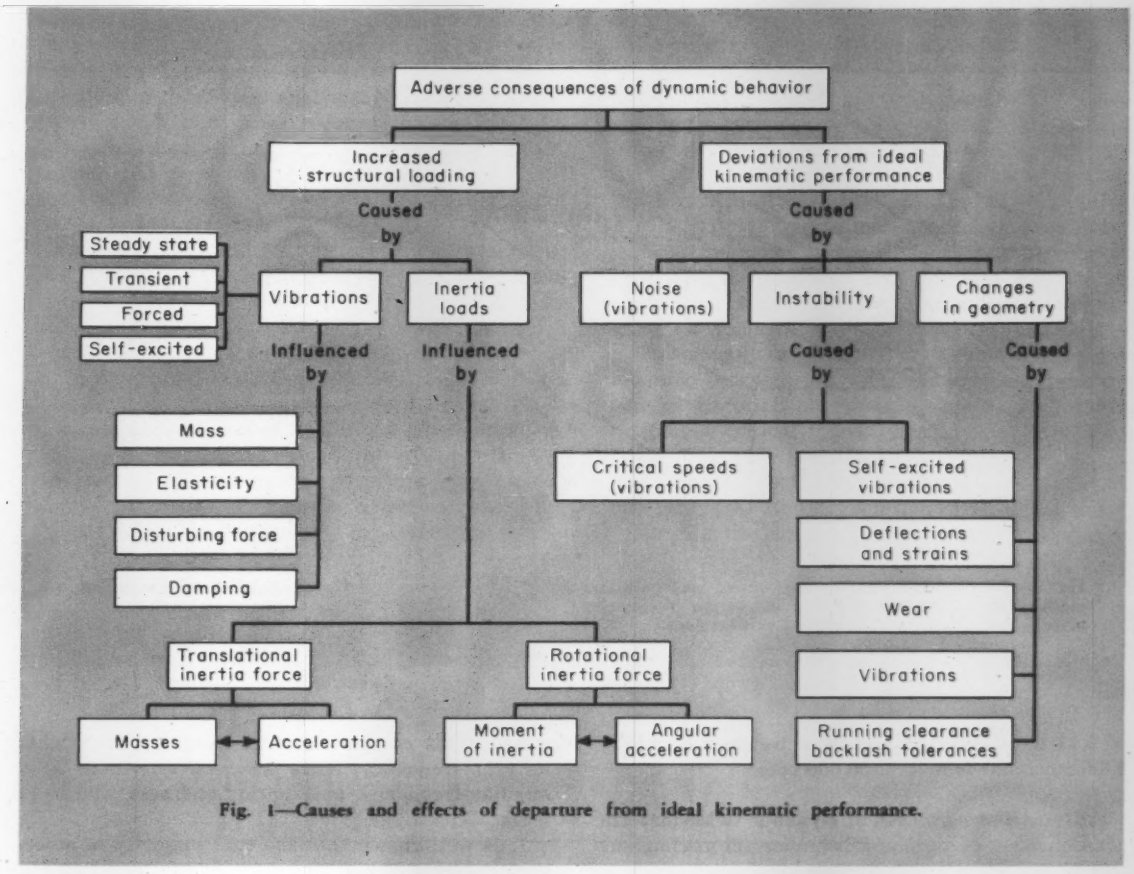

Fig. 1—Causes and effects of departure from ideal kinematic performance.

ways in which dynamic effects operate to bring about departures from strictly geometrical behavior are examined along with the causes.

Idealizing Assumptions: When a mechanism or a complete machine is examined theoretically from a strict kinematics standpoint, with all attention focused on motion and not its causes, assumptions are made which are usually incompatible with the actual physical conditions. The manner in which such idealized assumptions must be modified is discussed in following sections.

No Forces: Clearly, there are forces associated with the motions of all machine parts. For the complete design, the forces must be identified and evaluated so that parts may be properly proportioned. Power requirements for drivers and driven members must be predicted. Kinematic studies are frequently required to determine the accelerations needed to compute inertia forces as well as other information of value to the designer. For our present purposes, we need to be aware of the ways in which forces act to bring about deviations from the ideal kinematic performance.

Rigid Bodies: Having admitted the existence of forces in moving machine parts, we must now recognize that forces acting on elastic materials produce strains and deflections. Are these of sufficient magnitude to cause changes in geometry, and thereby invalidate the rigid body assumption?

Precise Dimensions: Manufacturing economy dictates the need for dimensional tolerances in machine components and in their assembly. Are deviations from the ideal configuration sufficient to affect performance? Bearing clearances and expansion or contraction due to ambient temperatures may also influence mechanisms in this fashion.

No Friction: Friction is inevitable between contacting parts in relative motion. The magnitude of the frictional effects is not always negligible.

Perfect Balance of Parts with Rotational Symmetry: Although certain machine parts may appear symmetrical on the drawing board, with the axis of rotation seeming to be a principal axis of inertia, imperfections arise in the manufacturing process. These deviations from symmetry are unknown prior to manufacture. Typical sources of unbalance include: 1. Manufacturing tolerances required in metals processing. 2. Tolerances necessary for assembly. 3. Distortion during operation. 4. Lack of homogeneity in the material. 5. Inability to control symmetry in assembly, as in winding armatures, application of impregnating materials and coatings.

The powerful influence of speed of rotation becomes apparent when it is recognized that, while 1 oz-in. of unbalance results in a centrifugal force

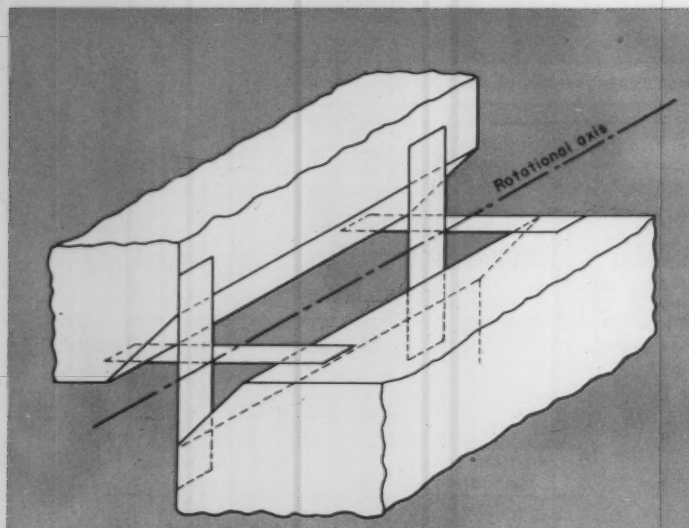

Fig. 2—Friction and wear in instrument and computer mechanisms can be minimized by use of the cross-spring pivot, shown here in symmetrical arrangement.

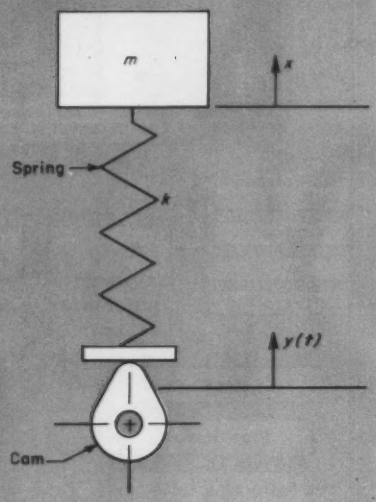

Fig. 3—Equivalent cam system.

of 0.44 lb at 500 rpm, the force becomes 44.3 lb at 5000 rpm, and 4430 lb at 50,000 rpm.

Adverse Consequences of Dynamic Behavior: The consequences of dynamic behavior of mechanisms which are significant to this discussion may be summarized in two categories: 1. Increased structural loading. 2. Tendency to produce deviations from the intended ideal kinematic (geometric) performance. These effects are outlined in Fig. 1.

INCREASED STRUCTURAL LOADING: It is recalled that by application of the principle of D'Alembert, stresses in a rigid body in accelerated motion can be calculated by application of the methods of statics. The body is considered to be in a state of equilibrium under the influence of external forces (or torques) and of inertia forces (or torques). It is well known that magnitude of the inertia force is a function of mass times acceleration of the mass center in translation, while for the case of rotation, inertia torque is a function of moment of inertia of the body about an axis through the mass center times the angular acceleration.

If stresses from dynamic sources are excessive, the designer may seek to reduce inertia forces through reduction of mass (for example, by the use of aluminum pistons in place of cast iron) or through reduction of acceleration, if kinetic specifications permit. In a rotational problem, mass distribution may be altered to decrease the radius of gyration, with decrease in moment of inertia.

The common method of reducing stresses (or excessive deflections) by increasing the size of the section involved may have a contradictory effect because of the accompanying increase of mass and, hence, the inertia force. A better approach is in the direction of greater stiffness and less mass. This is equivalent to designing for higher natural frequency, since $\omega^2 = k/m$, where ω = angular frequency, k = spring stiffness, and m = mass.

It is well-known that the vast majority of structural failures of machine parts are fatigue failures. In fact, it has been authoritatively estimated that over 80 per cent of machine-part service failures are due to fatigue. Fatigue failures are associated with cyclic stresses, which, in turn, are the result of vibration. Any body with elasticity and mass is capable of vibration, and moving machinery with unbalanced forces is especially prone to this phenomenon. Vibrations may be of a transient or steady-state type. They may be forced by external sources where the force is independent of the oscillatory motion, or they may be self-excited, with the sustaining force originating in the motion itself.

Literature on mechanical vibration theory[8] is extensive and continually expanding. The designer has at his disposal information useful in the analysis of a large variety of problems. For example, he may calculate the natural frequency of his device. By comparison with the frequency of the exciting forces, he can then determine the possibility of resonance, or the "critical speeds" at which stresses become excessive. In some instances, amplitudes of vibrations and vibration stresses may be estimated in preliminary design. Interaction of masses, springs, damping influences and exciting forces may also be examined. In mechanisms where low stress and precise control of movement of driven members are desired, the designer should strive for a high natural frequency of the device. Dangerous critical speeds should be avoided by at least 10 per cent.

Certain mechanical systems—either because of

their complexity, or because of the indefinite nature of the loading, as in cases of impact or other mechanical transients—are extremely difficult to handle in a theoretical analysis. In such instances, the designer may have recourse to experimental methods involving the use of dynamic strain gages, accelerometers, velocity pickups, stroboscopic light sources, high-speed photography[19] and other rapidly developing experimental techniques.

DEVIATION FROM IDEAL KINEMATIC PERFORMANCE: The designer of mechanisms may find the performance of his product departing from the ideal he hoped to achieve because of circumstances which are the outgrowth of dynamic behavior.

One source of departure obviously finds its origin in changes in the geometry of a mechanism. These changes may be brought about by strains and deflections of individual components. Corrective efforts are of the type discussed in the previous section in connection with stress reduction. Designing for a high natural frequency is again desirable.

A mechanism which is vibrating excessively will likewise exhibit undesirable deviations from its intended configuration. Other sources of geometric irregularity result from wear, backlash, excessive running clearances and tolerances. In extremely accurate instruments[23] and computer mechanisms,[7] backlash is reduced by careful construction. Ball bearings are often essential. Cross-spring pivots, Fig. 2, may be used to minimize friction and wear.[6]

Excessive noise in mechanisms may be traced to excessive clearance, wear, periodic impact, and vibration. Corrective procedures again may require an application of vibration theory.

Occasionally a machine or mechanism becomes unstable in operation. This is again a manifestation of vibration phenomena, such as a shaft running at a critical speed, "hunting" of a governor mechanism or other automatic control device, and various other self-excited vibrations. Again the designer must find his solution in vibration theory.

The significance of the preceding discussion be-

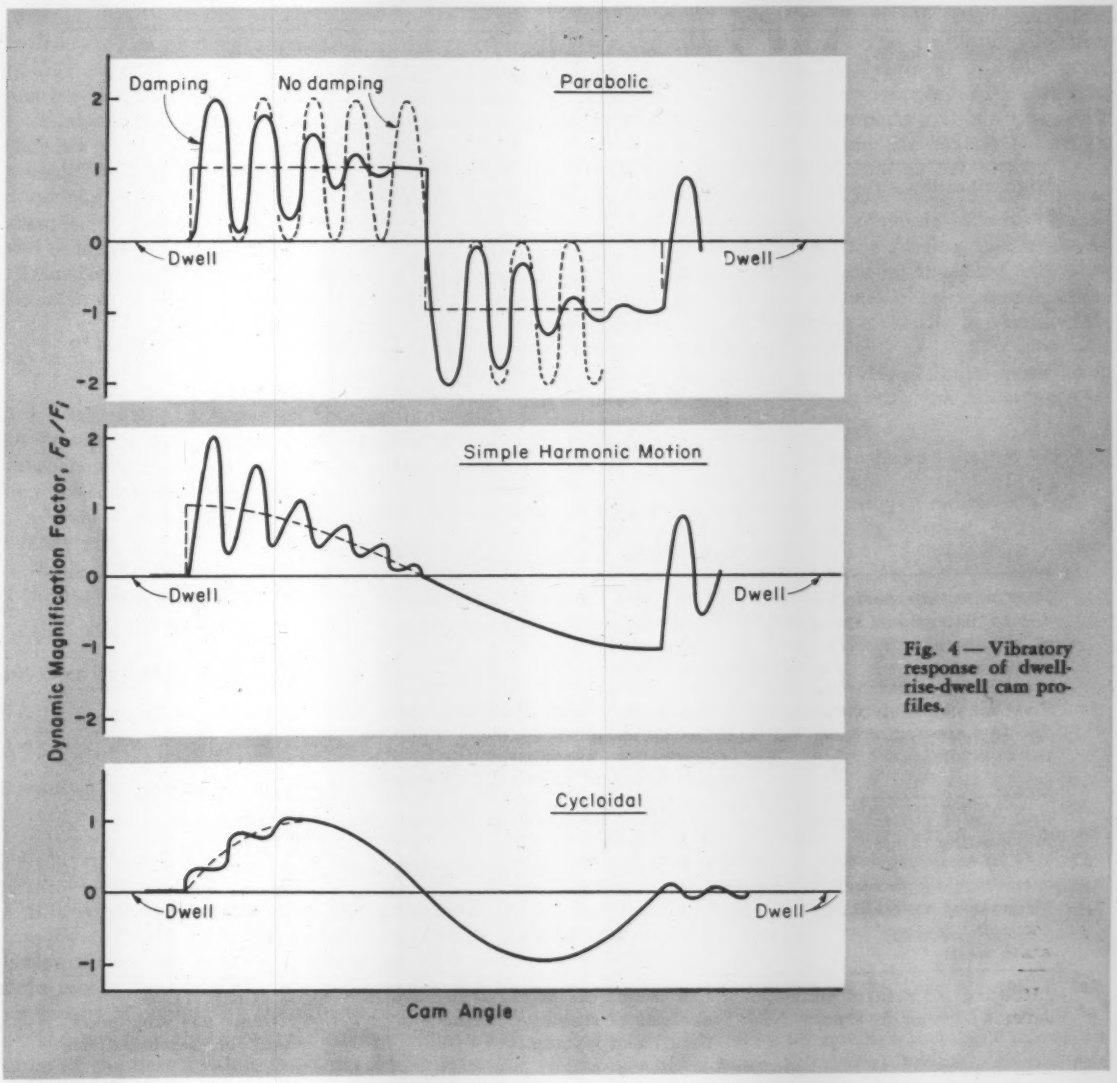

Fig. 4 — Vibratory response of dwell-rise-dwell cam profiles.

comes more apparent when applied to specific examples.

High-Speed Cam Design: For low-speed applications, the strictly kinematic or geometric approach has been traditional and adequate. The increasing number of high-speed cam applications, however, has brought the designer face to face with evidences of erratic behavior, vibrations, surface wear, noise and high inertia loads. Analysis of problems of this type requires a knowledge of dynamics, especially vibration theory.

Hrones[9] showed the influence of mass, elasticity and damping upon the forces in a cam-driven system. His studies and others have pointed up the difference between the command of the cam and the actual response of the follower mass. The development of the polydyne cam through the work of Dudley[20] and Stoddart[21] has been one of the efforts made to combat the undesirable aspects of dynamic cam behavior.

Rothbart[10] has listed the following sources of vibration in high-speed cam follower systems:

1. Vibrations influenced by the shape of the follower acceleration curve. If the slope of the acceleration curve becomes infinite, undesirable vibrations and stresses develop.
2. Vibrations arising from separation of cam and follower. This effect is sometimes called cross-over shock.
3. Vibrations caused by various types of irregular-

Table 1—Trouble Shooting Dynamic Effects

Problem	Suggested Corrections	References
High inertia loads	1. Reduce mass and/or moment of inertia by change of materials or redistribution of material. 2. Reduce acceleration by kinematic design.	3, 4, 5
High vibration stresses	1. Change natural frequency (raising it is usually preferable) by *a.* Change of masses. *b.* Change of elasticity (stiffness). 2. Remove or reduce disturbing forces by *a.* Balancing. *b.* Avoiding rapid changes of loading. *c.* Change of shape of force-time curve. *d.* Elimination of mechanical disturbances in gears, chains, belt splices, ball or roller bearings, couplings, etc. *e.* Eliminate geometrical irregularities and errors. 3. Use of dampers, absorbers, etc.	5, 8
Poor kinematic performance due to dimensional changes of members (deflections, strains)	Increase stiffness of parts in question. Design for high natural frequency.	8; Any good strength of materials text
Poor kinematic performance due to imperfect joints, pairs, pivots	Decrease friction, backlash, excess mechanical play, slippage. Improve lubrication, use cross-spring pivots, ball bearings, compensating devices.	6, 7, 23
Presence of critical speed in operating range	1. Change frequency of system (preferably raising it). 2. Use damping devices, absorbers, etc.	8 (Chap. 6)
Mechanical instability in form of "chatter" or shaft whirl	Frequently caused by "negative" friction, dry bearings. Improve lubrication.	8 (Chap. 7)
"Hunting" of control mechanisms such as governors	Use techniques of servo-mechanism analysis of stability. Methods of Routh and Nyquist.	8 (Chap. 7); 5 (Chap. 8); Any good text on servo-analysis

ities in the contact surfaces.

4. Vibrations resulting from external loads in the driver or driven system or transmitted through the frame.
5. Vibrations due to unbalance in the cam structure.

For the purpose of making a simplified dynamic analysis, the cam mechanism is represented by an equivalent system as shown in Fig. 3, where a cam follower of negligible mass is connected by a push rod or linkage equivalent to a spring of stiffness k, attached to the driven mass m. Let x represent the displacement of mass m, while $y(t)$ represents the motion of the lower end of the system as prescribed by the cam. Damping is neglected. By application of Newton's second law, the differential equation of motion of m is

$$\frac{md^2x}{dt^2} = k\left[\, y(t) - x \,\right] \tag{1}$$

Since $\omega^2 = k/m$, then

$$\frac{d^2x}{dt^2} + \omega^2 x = \omega^2 y(t) \tag{2}$$

Motion $y(t)$ is obviously dependent upon the cam contour chosen, and the form of the function influences the choice of method for solving the differential equation. Hrones[9] utilized the Differential Analyzer at M.I.T. on a similar system which also included viscous damping terms and was subjected to various cam contours. For the purposes of this example, the method of Laplace transforms[17] is used to indicate a solution.

Transforming the second order differential equation of motion into the subsidiary equation,

$$\bar{x}(s) = \frac{\omega^2 \bar{y}(s)}{s^2 + \omega^2} \tag{3}$$

This relationship is based on the assumption that the system is started from rest. After the inverse transformation is performed, displacement x can be found as a function of time t when $y(t)$ is specified in a transformable function.

If we are interested in the force F exerted on m by k, then we need to know the relative motion z of the ends of the spring, where

$$z = y(t) - x \tag{4}$$

and from Equation 1,

$$F = kz = \frac{md^2x}{dt^2} \tag{5}$$

The subsidiary equation in terms of F is

$$\bar{F}(s) = k\bar{z}(s) = ms^2\bar{x}(s) = \frac{m\omega^2 s^2 \bar{y}(s)}{s^2 + \omega^2} \tag{6}$$

In this equation, we detect in the numerator the term $s^2y(s)$, which represents the transform of the acceleration of the lower end of the spring (action of the cam). Thus we have at our disposal a convenient means of comparing the effects of the shape of the acceleration characteristic curves. The transforms of the acceleration characteristic curves can be used in Equation 6. The inverse transforms then represent the magnitude of a dynamic force. By comparing the actual force F_a with the inertia force F_i, which would be obtained if mass m were describing exactly the motion of the cam follower, we obtain a measure of dynamic magnification. The ratio F_a/F_i, defined as dynamic magnification factor D, therefore shows the force amplification directly attributed to the spring coupling between the cam follower and the mass m.

The effect of damping proportional to velocity can also be shown. This would be equivalent to the addition of a dashpot. The magnification factor then demonstrates the spring-dashpot coupling effect. Rothbart[10] has shown dynamic magnification factors for three basic dwell-rise-dwell cam curves, reproduced in Fig. 4. The curves show the vibratory nature of the response, as well as the dynamic magnification effect. These results show the cycloidal cam to have definite advantages over parabolic and simple-harmonic motion cams.

Another interesting aspect of dynamic effects may be shown by performing an inverse transformation on Equation 3, giving displacement x as a function of time t. The resultant equation may be solved for the displacement of mass m at the time when the cam has completed its rise and started to dwell. By comparing this value with the rise, we can determine the extent to which mass m falls short of its goal or overshoots.

Cam profile errors brought about by machining tolerances obviously have dynamic effects. Rothbart[10] presents a method for finding the acceleration effect of simple profile inaccuracies. He recommends that the allowable error acceleration not exceed 20 to 50 per cent of the maximum follower acceleration.

From dynamic considerations, high-speed cam systems should be designed with the following precautions:

1. Keep the slope of the cam acceleration curve (jerk) finite throughout.
2. Keep inertia loads low through control of acceleration magnitude and by keeping weight of moving parts low.
3. Design for rigidity and low mass of moving parts in order to have high natural frequency of the follower system.
4. Keep surface imperfections and profile inaccuracies to a minimum.
5. Minimize backlash and friction at mating surfaces.
6. Try to design the cam with minimum unbalanced mass.

General Observations: Current technical literature presents additional examples of dynamic effects in mechanisms. Typical problems of this type encountered by the mechanical disigner are summarized in Table 1. Suggested corrections and bibliographic references for background information are also given.

In general, the principal dynamic effects appear to involve inertia forces and vibration phenomena. Mass and flexibility of machine members therefore become ever more influential because of the de-

mand for higher speeds and generally improved kinematic performance. A knowledge of the dynamics of machinery, including vibration theory, becomes essential to the designer.

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN.

Transactions containing the 13 papers (104 pages) presented at the Conference are available at $2.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio (or see page 151).

The Fifth Conference on Mechanisms will be held at Purdue University, Lafayette, Ind., October 13 and 14, 1958.

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Tips and Techniques

Effective Area of Diaphragm

Determination of the proper values for the effective area and effective diameter of circular diaphragms used in mechanism design is often a problem.

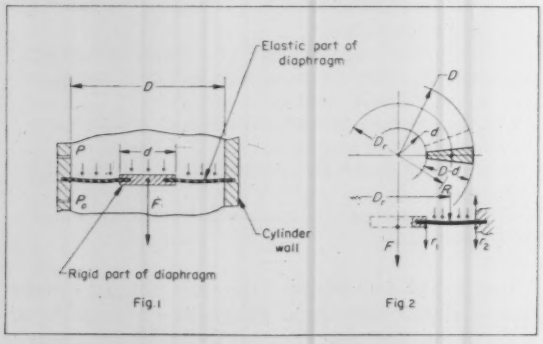

Fig. 1

Fig. 2

The accuracy of the diaphragm force F, Fig. 1, calculated from the formulas:

$$F = (P - P_0)A_e$$

or

$$F = \frac{(P - P_0)\pi D_e^2}{4}$$

where $P - P_o$ is the pressure differential, depends upon the determination of A_e, the effective area, or D_e, the effective diameter.

When exactness is not a criterion, or when the difference between outside and inside diameters of the elastic area $D - d$ is small, less precise determinations such as $D_e = (D + d)/2$ and $A_e = D_e^2/4$ may be used.

However, when precision is important the following formulas are suggested:

$$D_e = \sqrt{\frac{D^2 + Dd + d^2}{3}} \qquad (1)$$

or

$$A_e = \frac{\pi(D^2 + Dd + d^2)}{12} \qquad (2)$$

These formulas are derived by treating the elementary portion of the diaphragm, Fig. 2, as a uniformly loaded trapezoidal beam. The component r, of the resulting force R contributes to the diaphragm action whereas the r_2 component remains inactive. The point of action of R is assumed to be at the center of gravity of the element which has a center of gravity radius of $2(D^2 + Dd + d^2)/3(D + d)$.

Equations 1 and 2 are precise for most applications. However, for extreme accuracy, they may be modified by correcting coefficients. — NICHOLAS BASKEVITCH, *James K. Mosher Co., Pasadena, Calif.*

Three approximation methods for **Finding Roots of Equations** *to any desired accuracy*

By RAYMOND C. BOUCHER
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Hamden, Conn.

EQUATIONS such as $x^2 + x = 3$ and $x^3 + x = 5$ can be solved rather easily by the common quadratic and cubic solutions. But finding the exact value or values of x in polynomial expressions with higher, fractional, or mixed powers is not as easy. Trial-and-error solutions can be attempted. But systematic methods of approximation are far more satisfactory, especially if any required degree of accuracy can be obtained.

Three methods of approximation for finding real roots are outlined in this article. Although none of them produce theoretically exact solutions, the methods can give any desired degree of accuracy. They involve repetitive steps, giving successive approximations that converge upon the exact solution. Where and when to use one of the methods in preference to another is a choice dependent upon ease of solution relative to required accuracy.

Preliminary Steps: For each of the three methods, the first step is to rearrange the equation to make it equal to zero. For example, express $x^4 - x^3 = 7$ as $x^4 - x^3 - 7 = 0$. Then, let $y = f(x)$. That is, $y = x^4 - x^3 - 7$.

Next, roughly plot $y = f(x)$ in the region of $y = 0$. The exact root of the equation is the point on the x axis ($y = 0$) through which the curve passes. Finding an approximate value of x for $y = 0$ is the basis for each of the three methods.

Method 1: A plot of the locus of $y = f(x)$, Fig. 1, shows that a real root exists at r, since at this point on the curve $y = 0$.

To approximate this root, select two points on the locus, A and B, so located that they give opposite signs to $f(x)$. Draw secant line AB and write its equation:

$$\frac{y - f(a)}{x - a} = \frac{f(b) - f(a)}{b - a} \qquad (1)$$

The value of the first root approximation is given at the point where AB crosses the x axis. Substitute $y = 0$ in Equation 1 and solve for x, denoting this first approximation as a_1:

$$a_1 = a + \frac{(a - b)f(a)}{f(b) - f(a)} \qquad (2)$$

To obtain the next closer approximation, repeat the procedure, using A_1 in place of A. Point A_1 is on the curve directly under a_1. This second approximation of x is

$$a_2 = a_1 + \frac{(a_1 - b)f(a_1)}{f(b) - f(a_1)} \qquad (3)$$

The approximation of r, to any degree of accuracy desired, can be obtained by repeating the analysis with successive points (A_2, A_3, etc.).

EXAMPLE: Approximate the real root of $x^3 + x = 5$. Roots of this equation can be evaluated, of course, by the cubic solution. Since the exact real root can be found, this example permits easy observation of approximation errors.

Express the equation as a function of y. That is, $y = x^3 + x - 5$.

A rough plot indicates that root r lies between 1 and 2 on the x axis. Arbitrarily, therefore, $a = 1$ (the abscissa of A) and $b = 2$ (the abscissa of B). Solve for y by substituting for x these values of a and b. The resulting ordinates of A and B are $f(a) = -3$ and $f(b) = 5$.

Solve for the first approximation by substituting these values in Equation 2:

$$a_1 = 1 + \frac{(1 - 2)(-3)}{5 - (-3)} = 1 + \frac{3}{8} = 1.375$$

Begin the next approximation by finding the co-ordinates of new point A_1. The abscissa is $a_1 = 1.375$. With this value, solve for y to obtain the ordinate: $f(a_1) = -1.0254$. This ordinate is a measure of remaining error since it must reach zero for the exact solution.

Substitute these co-ordinate values and those for

point B in Equation 3 to determine the second approximation: $a_2 = 1.481$.

Repeat the process to obtain the third approximation: $a_3 = 1.507$.

Method 2: This procedure is a variation of Method 1. As Fig. 2 shows, the curve is again plotted and points A and B selected. Then, construct triangle AOB. By similar triangles,

$$\frac{a_1 - a}{f(a)} = \frac{(OB)}{(AO)}$$

or

$$\frac{a_1 - a}{-f(a)} = \frac{b - a}{f(b) - f(a)}$$

Therefore, the first approximation of x is

$$a_1 = \frac{af(b) - bf(a)}{f(b) - f(a)} \tag{4}$$

In the same manner as Method 1, determine coordinates of new point A_1. Construct triangle A_1OB. Calculate the second approximation from

$$a_2 = \frac{a_1 f(b) - bf(a_1)}{f(b) - f(a_1)} \tag{5}$$

EXAMPLE: Find the roots of the example equation from Method 1. Initial co-ordinate values are the same.

Substitute values in Equation 4 to obtain the first approximation:

$$a_1 = \frac{(1)(5) - (2)(-3)}{5 + 3} = \frac{11}{8} = 1.375$$

It is easy to observe that the arithmetic of this method is identical to that of Method 1. Only the initial geometric approach differs.

Method 3: Place points A and B on a plot of the curve in the same way as for Method 1. Draw secant AB and the tangents at A and B.

Take the first derivative of $y = f(x)$, as the first step in finding the equations of the tangents. Evaluate the derivative at points A and B. The equation of the tangent at point A is

$$y = (x - a)f'(a) + f(a) \tag{6}$$

At point B,

$$y = (x - b)f'(b) + f(b) \tag{7}$$

Determine abscissa $x = h$ for tangent intersection I by solving Equations 6 and 7 simultaneously:

$$h = \frac{f(b) - f(a) + af'(a) - bf'(b)}{f'(a) - f'(b)} \tag{8}$$

Evaluate ordinate k of I by substituting the value of h for x in either Equations 6 or 7.

Next, find the equation of the line from intersection I to point C, located on the y axis at the

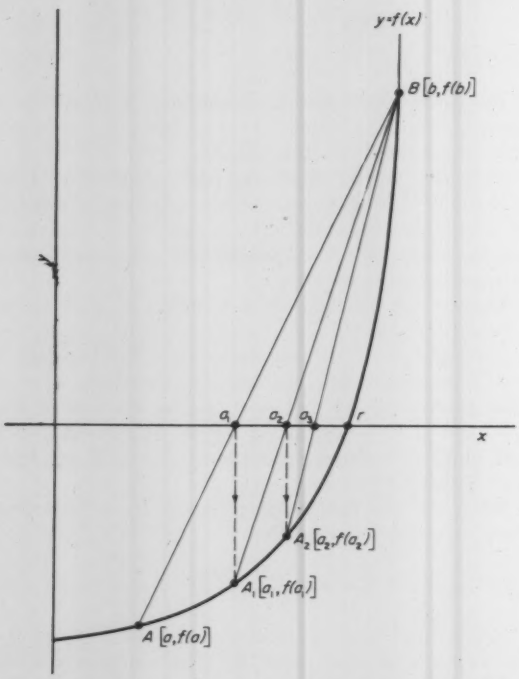

Fig. 1—Method 1. A line joining points A and B, arbitrarily located on the plot below and above the x axis, fixes the first approximation at a_1. Successive approximations, a_2, a_3 etc., are obtained with points A_1, A_2, etc.

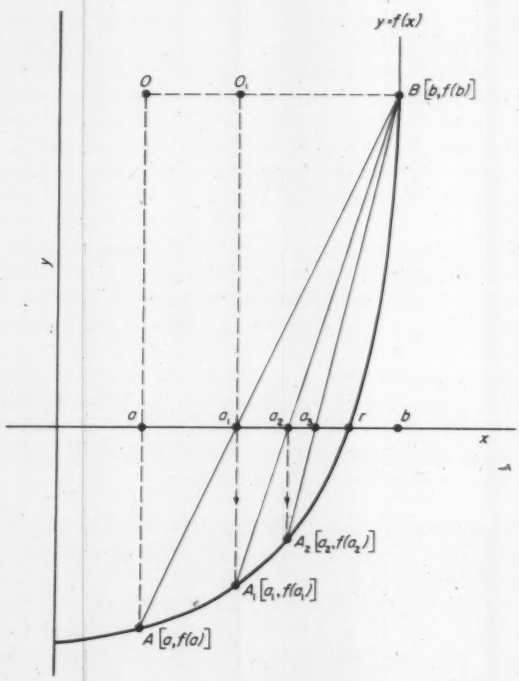

Fig. 2—Method 2. Varying only in geometric approach, this method is the same as Method 1 in computation details and results

ordinate value of point B:

$$\frac{y-k}{x-h} = \frac{f(b)-k}{-h} \tag{9}$$

For new intersection I_1, find abscissa a_1 by solving Equations 1 and 9 simultaneously:

$$a_1 = \frac{hb[f(b)-f(a)]}{h[f(b)-f(a)]+k(a-b)+(b-a)f(b)} \tag{10}$$

The value of a_1 is the first approximation of x.

As the first step in finding the second approximation, locate the point A_1 on the curve directly beneath a_1. Find the ordinate of A_1 by substituting a_1 for x in $y = f(x)$. Write the equation for the tangent at point A_1:

$$y = (x-a_1)f'(a_1) + f(a_1) \tag{11}$$

Solve for its intersection a_2 with the x axis:

$$a_2 = a_1 - \frac{f(a_1)}{f'(a_1)} \tag{12}$$

The value of a_2 is the second approximation of x.

Determine the ordinate on the curve corresponding to the abscissa a_2. Write the equation of the tangent at this point on the curve. Find the intersection of the tangent with the x axis. This point is the third approximation of x.

The initial secant and tangent construction leads to a first approximation which, in effect, becomes the starting point for the application of Newton's method. Under certain conditions, the next approximation (the first by Newton's method) may not be as close as the first. But successive approximations will converge toward the exact value.

If these conditions can be observed, and sufficient accuracy seems likely, certain points in the initial construction may actually be closer to the exact root than the one identified as the first approximation.

For example, when either A or B is close to the x axis, the intersection of the tangent through the point closest to the x axis is a closer approximation than a_1. Substitute $y = 0$ in Equation 6 for the tangent at point A, and Equation 7 for the tangent at point B, to obtain this new first approximation.

When intersection I falls below the x axis, the abscissa of intersection I is usually a closer approximation than a_1. Obtain this new first approximation from Equation 8.

If I falls above the x axis, the abscissa of I_1 is usually the closest first approximation, and is obtained from Equation 10.

EXAMPLE: Find the roots of the example from Method 1. Initial co-ordinate values are the same.

It is observed that points A and B are far enough from the x axis that a_1 is the closest first approximation.

As a first step in determining a_1, calculate the first derivative of $y = f(x)$ at A and B. The first derivative of $y = x^3 + x - 5$ is $y' = 3x^2 + 1$. At A, $f'(a) = 3(1)^2 + 1 = 4$. At B, $f'(b) = 3(2)^2 + 1 = 13$.

Next substitute these values in Equation 8 to obtain the abscissa of I: $h = 14/9$. Using this value, calculate the ordinate of I: $k = -7/9$.

It is apparent from these results that I lies below the x axis. Therefore, h is used as the first approximation; it may be closer the exact root than a_1.

The first step in determining the second approximation is to locate the point on the curve that has the same abscissa value as h. Determine the ordinate, and calculate the first derivative of $y = f(x)$ at this point.

Substitute these values in Equation 12 to obtain the second approximation: $a_2 = 1.555 - (0.319/8.259) = 1.516$. Substitution of this value for x back into the original equation gives an answer of zero to three decimal places. This result indicates that the exact root is very closely approximated.

Accuracy: A recap of results of the root approximations by the three methods serves as a guide to the accuracy, or rapidity of approximation, of each. Both Methods 1 and 2 give first, second, and third approximation values of 1.375, 1.481, and 1.507. Method 3 gives a first value of 1.555 and a second of 1.516, almost the exact root. It can be concluded that, although Methods 1 and 2 are easier to apply, more approximations must be made to obtain the accuracy of Method 3.

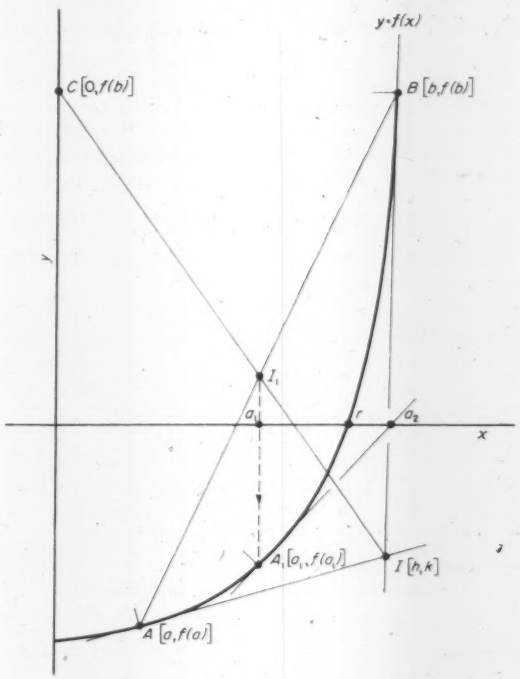

Fig. 3—Method 3. Differing only in construction to obtain the first approximation, this procedure is the same as Newton's method in its use of successive tangents

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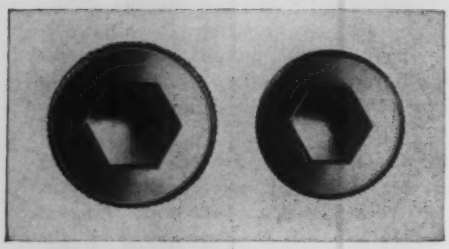
have design features that provide higher reliability in all sizes by increasing usable fastener strength as much as 134%



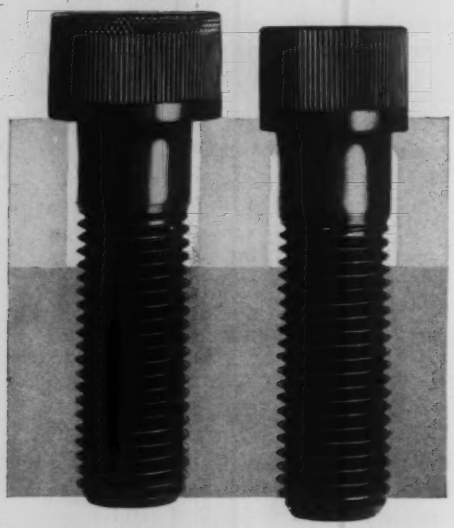


ILLUSTRATION COMPARES NEW UNBRAKO pHd cap screw (left) with same size screw of ordinary design. The larger head of the UNBRAKO pHd can carry much greater loads without indenting into the bolted material. This means greater clamping force and longer fastener life under dynamic loads. The larger socket in the UNBRAKO pHd makes possible greater repetitive tightening.

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- Elimination of washers under the heads of cap screws in many applications where they are used to increase the effective bearing area.
- Minimization of effects of oversized holes on the head-bearing area and resulting increase in holding power.

The bearing area surface of the new UNBRAKO pHd, enlarged to hold the bearing stress to 80% of the axial tensile load on the screw, increases the holding power of the screw by as much as 2⅓ times. The head diameter increase, a maximum of 17% in the larger sizes, increases usable fastener strength as much as 134%. This means greater clamping force and longer fastener life under dynamic loads in tension applications. The head diameters, enlarged on 5/16, 7/16, 9/16, ¾, ⅞ and 1 in. body diameters, also prevent the screw head from indenting the material being assembled—a fault that normally reduces, and sometimes even dissipates, the vital preload or tensile stretch that keeps the screw tight and prevents fatigue failures. The larger head diameter also provides room for a bigger wrenching socket where required and this, in turn, makes tightening to designed preload easier and more certain.

The new UNBRAKO pHd socket cap screws are now available through authorized industrial distributors at no increase in prices. Specify them when ordering. Also available with Nylok† self-locking feature. For technical data and specifications, send for Bulletin 2406. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

COMPARISON OF UNBRAKO pHd AND CONVENTIONAL DESIGN

Each size can now be utilized with equal reliability. The bearing stress is consistent from size to size in the new UNBRAKO pHd socket cap screws.

SCREW SIZE	HEAD DIAMETER (in.)		BEARING AREA (sq. in.)		LOAD TO INDENT IN CAST IRON (lb.)		% INCREASE USABLE STRENGTH	TIGHTENING TORQUE (lb.-in.)‡	
	Old	pHd	Old	pHd	Old	pHd		Old	pHd
¼	.375	.375	.041	.041	3,280	3,280	—	165	180
5/16	.438	.468	.047	.072	3,760	5,760	54	325	360
⅜	.562	.562	.102	.102	8,150	8,150	—	600	660
7/16	.625	.656	.116	.148	9,270	11,800	27	1,000	1,040
½	.750	.750	.188	.188	15,000	15,000	—	1,450	1,590
9/16	.875	.937	.203	.305	16,200	24,400	51	2,900	3,190
¾	1.000	1.125	.223	.432	17,800	34,600	94	5,050	5,600
⅞	1.125	1.312	.254	.594	20,300	47,500	134	8,000	8,900
1	1.312	1.500	.364	.785	29,100	62,800	116	10,550	13,600

‡Normal recommended seating torques for unplated screws, fine threads

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DESIGN ABSTRACTS

electrical

Selecting Reliability Levels In Equipment Design

Harold L. Garbarino, Armour Research Foundation

A review of the problem of reliability in electronic equipment. It is recommended that reliability be considered as a design parameter together with other performance requirements. Concepts and techniques available for measuring reliability levels are included.

IRE Transactions on Industrial Electronics, *PGIE-5, April,* 1958; *Page* 76.

Wiring Diagrams—Their Purpose And How to Understand Them

F. R. Cinco, Reed-Prentice Corp.

An approach to analyzing circuit diagrams by means of a systematic breakdown of basic circuits. Functions of electrical components such as limit switches, relays, and circuit breakers are explained and shown symbolically in the circuits.

SPE paper 77, *from Proceedings of the* 14*th Annual National Technical Conference, Detroit, January,* 1958; 5 *pp.*

Direct-Contact Cooling of Airborne Electronic Equipment

T. Jordan, Sylvania Electric Products Inc.

A brief explanation of principles of forced-air direct-contact cooling is given to show that heat density of the part being cooled determines the range of applicability of this method. Techniques are included for obtaining high heat-transfer coefficients and good air distribution with small pressure drops. Application of thermal insulation to direct-contact cooling are pointed out.

IRE Transactions on Aeronautical and Navigational Electronics, *Vol. ANE-5, No.* 1; *page* 25.

Thermal Stability of Silicone Dielectrics

D. F. Christensen, Dow Corning Corp.

Discussion of thermal stability and radiation resistance of silicone dielectrics. Information tells designers how to use maximum thermal stability of silicones, and shows that useful life of silicone insulation depends on physical rather than electrical-property charges.

From "Evaluating the Thermal Stability and Radiation Resistance of Silicone Dielectrics," IRE Transactions on Component Parts, *Vol. CP-5, No.* 2, *June,* 1958; *pp.* 108-115.

Magnetic Type Transducers In Industrial Electronics

David L. Elam, Electro Products Laboratories Inc.

Characteristics of magnetic pickups with regard to practical applications. Principles of operation are covered briefly, and mechanical construction is developed in progressive steps. Models for both low and high-temperature applications are described.

From "Magnetic and Eddy Current Type Transducers for Use in Industrial Electronics," IRE Transactions on Industrial Electronics, *PGIE-6, May,* 1958; *Page* 29.

Forced-Convection Cooled Electronic Equipment

Lawrence Fried, General Electric Co.

How temperature affects life, reliability, and operating characteristics of electronic components. This analysis of temperature prediction is limited to surface temperatures of parts cooled by forced convection.

IRE Transactions on Component Parts, *Vol. CP-5, No.* 2, *June,* 1958; *pp.* 102-107.

materials

Silicone Foams

D. E. Weyer, Dow Corning Corp.

A report on the development of silicone foams to present-day available formulations. Equipment necessary for maintaining foam density and physical properties is discussed. Also included is an evaluation of the foam as thermal insulation.

SPE paper 82, *"Room Temperature Setting, Heat Resistant, Low Density Silicone Foams," from Proceedings of the* 14*th Annual National Technical Conference, Detroit, January,* 1958; 7 *pp.*

Cermets as Potential Materials For High-Temperature Service

O. A. Sandven

Mechanical, chemical, and physical properties of the most important and promising hard metals and cermet systems. Special attention is given to creep resistance and ductility. Some experimental results on the titanium-carbide and nickel system are included.

NATO Report 99, *from Fifth Meeting of Structures and Materials Panel, Oslo, Norway;* 24 *pp.*

Properties and Uses of New Silicone Resins

Melvin E. Nelson, Dow Corning Corp.

A report on a new system of silicone resins produced in a solvent-

free state which makes them usable in applications never before possible. Two of these new resins are now available commercially in a form especially valuable for impregnation and potting of electrical devices. Physical and electrical properties and applications are covered.

SPE paper 54, "Properties and Applications of the New, Low Viscosity, Solventless, Thermosetting Silicone Resins," from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 10 pp.

Teflon 100-X

R. S. Mallouk and W. B. Thompson, E. I. duPont de Nemours & Co. Inc.

Report on a new fluorocarbon polymer having a melt viscosity one millionth that of Teflon 1 and permitting melt extrusion of wire coating, rod, and tubing. Products produced from Teflon 100-X have a unique combination of electrical properties, chemical inertness, low permeability, and retention of physical properties to 480 F. Physical properties at elevated temperatures are covered as well as electrical and chemical properties and applications.

SPE paper 75, "Teflon 100-X Perfluorocarbon Resin—A New Melt-Extrudable Fluorocarbon Resin," from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 13 pp.

Ceramic Coatings of Engines

Paul A. Huppert, Gulton Industries Inc.

A treatment of application techniques of modified ceramic coatings for alloys subject to extremely high temperatures. Requirements of ceramic coatings, other than conventional heat resistance, are covered. Methods of applying these ceramic coatings include flame spraying, solution ceramics, and surface layer deposition. Tabular data give complete physical and chemical properties of ceramic lithium, complex lithium, and superrefractory compounds.

ARS paper 588-58, from ASME-ARS Joint Aviation Conference, Dallas, March, 1958; 22 pp.

Selected Properties of High-Temperature Materials

D. A. Shinn

Supplementary information on design criteria for titanium alloys and competitive materials. Report covers static properties, compression tests, short-time tensile tests, creep and rupture characteristics, and other information necessary for detailed design of high-temperature structures.

NATO Report 104, from Fifth Meeting of Structures and Materials Panel, Oslo, Norway; 40 pp.

Structural Plastics For Airframe Construction

N. J. L. Megson

A general account of development and fabrication of reinforced plastics which can be molded at low pressures. In particular, plastics based on glass and on asbestos are considered. Detailed properties are compared to those of other materials, and differences between plastics and metals are emphasized, especially in the interpretation and use of test data. Future trends of plastics are mentioned and research work outlined.

NATO Report 162, from Fifth Meeting of Structures and Materials Panel, Oslo, Norway; 16 pp.

mechanical

Rheological Considerations In Plastic Product Design

Bryce Maxwell, Princeton University Plastics Laboratory

A discussion of why rheology, the science of deformation of material, is important in design of components from materials in the solid state. This paper points out the inadequacy of current methods of reporting engineering properties of materials and discusses methods of determining nonideal time and temperature dependencies of material characteristics.

SPE paper 99, from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 11 pp.

Helical Springs of Hollow Circular Cross-Section

C. W. Bert, Battelle Memorial Institute

A theoretical and experimental investigation of elastic shear stresses and deflection in an axially loaded helical spring having a hollow, circular cross-section. Two analyses are made: An approximation of stresses by the strength-of-materials theory, and a more accurate elasticity-theory solution. Results are compared with strain and deflection measurements on an actual tubular spring.

ASME paper 58-SA-18, from 1958 Semiannual Meeting, Detroit; 6 pp.

Merit Indices for Structural Materials

H. B. Howard

Merit indices giving weight efficiency for a number of simple structural properties including direct strength and stiffness, wrinkling of thin-walled tubing, and thermal stress and deformation. Indices are applied to typical aluminum and titanium alloys and to a stainless steel at temperatures to 750 F.

NATO Report 105, from Fifth Meeting of Structures and Materials Panel, Oslo, Norway; 24 pp.

Causes of Drift of Gyroscopic Instruments

R. M. Stewart, Jet Propulsion Laboratory

Ingenious component and system designs have reduced bearing friction and mass unbalance in gyroscopic instruments to minimize random drift of indicated stable directions. Other sources of drift may occur which are aggravated by high vibration levels and fast rotational response to external disturbances. This paper describes and partially analyzes some significant mechanisms by which vibration induced drifts may occur and indicates some means of alleviating them.

ARS paper 644-58, "Some Effects of Vibration and Rotation on the Drift of Gyroscopic Instruments," from Semiannual Meeting, Los Angeles, June, 1958; 19 pp.

Industrial Digital Systems

E. J. Otis, Daystrom Inc.

Discussion of basic reasons why digital equipment, rather than analog equipment, is preferable for control systems. Characteristics of system components are covered, and broad design criteria are developed for their construction.

IRE Transactions on Industrial Electronics, *PGIE-6, May,* 1958; *Page* 73.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 31, N. Y.

SPE—Society of Plastics Engineers Inc., 34 East Putnam Ave., Greenwich, Conn.

NATO—North Atlantic Treaty Organization, National Advisory Committee for Aeronautics, 1512 H St. N.W., Washington 25, D. C.

ARS—American Rocket Society, 500 Fifth Ave., New York 36, N. Y.

ASME—American Society of Mechanical Enginers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

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Circle 462 on Page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Hydraulic Cylinders

Catalog 900 contains design and performance information on Powrdraulic hydraulic cylinders for 2000-psi standard service and 3000-psi nonshock service. Cylinders are available with 1½ through 8-in. bores in a wide range of mounting styles. 8 pages. Hanna Engineering Works, 1765 N. Elston Ave., Chicago 22, Ill. I

Circle 561 on Page 19

Relief Valves

"Selection of Relief Valves for Commercial Refrigeration and Air Conditioning Applications Based On ASA-B9.1 Code" is title of Bulletin 58-28. It affords guidance in choosing the right size valve for a given application. 4 pages. Superior Valve & Fittings Co., 1509 W. Liberty Ave., Pittsburgh 26, Pa. F

Circle 562 on Page 19

Resin Adhesives

Catalogued in illustrated bulletin "Epoxy Resin Adhesives" are various types of chemically-activated adhesives for bonding steel, iron, plastics, ceramics, wood, glass, and hard rubber to themselves or to each other. Offered are $1 trial test kits to aid in choosing the proper adhesive for a given bonding need. 20 pages. Armstrong Products Co., Argonne Road, Warsaw, Ind. J

Circle 563 on Page 19

Hydraulic Pumps

Performance and design characteristics of High Performance Balanced Vane pumps are discussed in Bulletin M5108. Pumps operate at speeds to 2000 rpm at pressures to 2000 psi, and six models have capacities from 17.8 to 43 gpm. 4 pages. Vickers Inc., Detroit 32, Mich. H

Circle 564 on Page 19

Electric & Lubricating Devices

Various types of Trico electrical devices such as fuses, fuse pullers, reducers, and fuse and test clamps, as well as a complete line of automatic oilers for lubricating machines and equipment are described in Condensed Catalog No. 58. 8 pages. Trico Fuse Mfg. Co., 2948 N. Fifth St., Milwaukee 12, Wis. K

Circle 565 on Page 19

Equipment Coolers

"Cooling Packages" is descriptive of compact units designed for applications requiring a liquid-cooled heat exchanger. Packaged units consist of a pump, motor, fan, housing, and heat exchanger. Heat transfer rate is 1720 Btu per hr. 4 pages. Borg-Warner Corp., Pesco Products Div., 24700 N. Miles Rd., Bedford, Ohio. G

Circle 566 on Page 19

Silicone Insulations

Offered as a selection guide to silicone insulating components, Bulletin 10-109 also illustrates the step-by-step procedure for winding electric motors. Properties are tabulated for materials and components for insulation systems of several different temperature classes. 6 pages. Dow Corning Corp., Midland, Mich. H

Circle 567 on Page 19

Missile Component Testing

Laboratory facilities for advance structural testing, especially in the area of missile components, are described in Brochure 57SD129. It deals with structural static and dynamic testing, experimental stress analysis, hydraulic and pneumatic testing, and other types. 16 pages. General Electric Co., Missile & Ordnance Systems Dept., Room 5B, 3198 Chestnut St., Philadelphia 4, Pa. C

Circle 568 on Page 19

Temperature Controller

Offered with ranges from −150° to 200° F to 50° to 700° F, Model 541 temperature indicating controllers are made in a variety of standard and tailor-made styles. Design, operating, and application features of these controls are given in Bulletin MC-168. 4 pages. Fenwal Inc., Pleasant Street, Ashland, Mass. B

Circle 569 on Page 19

Self-Locking Nuts

Design Manual 5803 reviews standard and miniature types of self-locking clinch nuts for use in avionic, electrical, and electronic equipment. These clinch nuts are self-retaining, self-locking, shank type fasteners especially suited for attaching cover plates or mounting component metal or plastic panels. 18 pages. Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J. D

Circle 570 on Page 19

Range Timers

Expressly designed for use on electric ranges, line of automatic timers described in Bulletin 165 includes synchronous-motor driven types. 2 pages. Lux Clock Co., Waterbury 20, Conn. B

Circle 571 on Page 19

Storage Batteries

Detailed technical data on the use of stationary storage batteries are compiled and presented in Bulletin 210. It discusses the selection of batteries and charging equipment, proper battery and charger maintenance, selection of battery racks, and determination of battery discharge rates. 24 pages. Electric Storage Battery Co., Exide Industrial Div., Box 8109, Philadelphia 1, Pa. E

Circle 572 on Page 19

Acoustic Generator

Details of the new Model 375-H high intensity driver are given in Data Sheet T1-1. Features of this precision acoustic generator include a titanium diaphragm, high energy output to 10,000 cps, large voice coil, and advanced magnetic circuitry. Transducers, Inc., 2957 Honolulu Ave., La Crescenta, Calif. L

Circle 577 on Page 19

Rotary Air Motor

The Keller Model 71A-1 rotary air motor described in Catalog Section 71 is rated ⅛ hp, and is available with full-load output speeds of 9000, 2375, and 475 rpm or respective free speeds of 20,000, 5000, and 1000 rpm. Air consumption is 10 cfm. Gardner-Denver Co., Quincy, Ill. I

Circle 573 on Page 19

Cam Timers

Synchronous motor driven cam timers described in Bulletin 200 include recycling, single cycle, multicam recycling, and single cycle multicam types. Gear rack chart facilitates specifying hundreds of combinations. 4 pages. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J. D

Circle 574 on Page 19

Teflon Rod Stock

Available sizes, engineering data, tips on machining, and typical uses for Teflon rod are some of the information contained in Fact Sheet No. 1. Rod is available in diameters from 1/32 to 2 in. in extremely small increments. 4 pages. Chemplast, Inc., 3 Central Ave., East Newark, N. J. D

Circle 575 on Page 19

Gearshift Transmissions

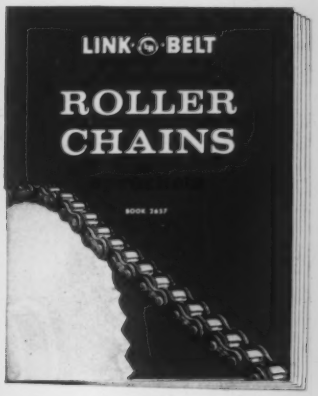
Complete specifications and performance data on four gearshift type transmissions for machine and equipment drives are contained in technical bulletin. Capacities range from 1 to 60 hp. 2 pages. Western Mfg. Co., 3400 Scotten Ave., Detroit 10, Mich. H

Circle 576 on Page 19

Motor Speed Control

"How to Maintain Constant Motor Speed" is title of Bulletin 558-1 which

NEW roller chain engineering data book



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Circle 464 on Page 19

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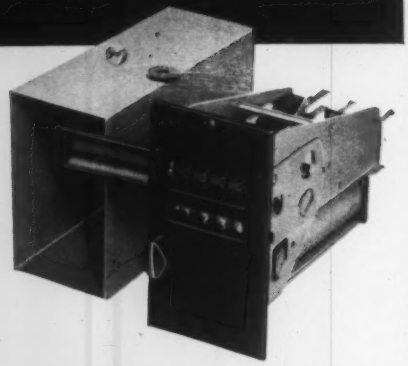

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45 West 45th Street, New York 36, N. Y.

Circle 465 on Page 19

describes the new Fincor alternating and direct current motor controls. They utilize static magnetic amplification to maintain desired motor speed regardless of load variations. 4 pages. Fidelity Instrument Corp., 1000 E. Boundary Ave., York, Pa. E

Circle 578 on Page 19

Lock Nuts

Locking ability, axial strength, and prices and specs of standard and high load, standard thin and high load thin, and standard thick and high load thick Stover Lock Nuts are tabulated in illustrated bulletin which also explains design and applications of these fasteners. 6 pages. Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland 9, Ohio. G

Circle 579 on Page 19

Flexible Couplings

Revised Bulletin 10100A contains data on ten sizes of Sure-Flex flexible couplings with ratings from 0.09 to 11.4 peak hp at 100 rpm, or 1.5 to 200 hp at 1750 rpm. Bores range from ⅜-¾ in. in smallest coupling to 2⅜-2⅞ in. in largest size. Tables aid is selection and application for specific drive needs. 8 pages. T. B. Wood's Sons Co., Chambersburg, Pa. E

Circle 580 on Page 19

Conveyor Idlers

Bulletin 925 is a technical and pictorial presentation of the story of the Permaseal idler for belt conveyors and systems. Bearings are grease-sealed and have permanent factory lubrication. Typical installations in mining, industry, and other materials handling applications are shown. 8 pages. Jeffrey Mfg. Co., Columbus 16, Ohio. G

Circle 581 on Page 19

Plastics Materials

Catalog and price list of materials for fibrous glass reinforced plastics includes glass fiber fabrics and fibers, polyester and epoxy resins and catalysts, parting agents, and pigments. Glass fiber cloths, tapes, woven rovings, mats, and milled fibers are also listed. Available sizes and grades are covered. 16 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 582 on Page 19

Molded Resin Parts

Fluorosint TFE resin, a polytetrafluoroethylene base composition available in molded parts, is subject of Bulletin BR-9. It improves the mechanical and thermal properties of the pure material without affecting its electrical and chemical characteristics. Data on properties are given. 4 pages. Polymer Corp. of Pa., 2140 Fairmont Ave., Reading, Pa. C

Circle 583 on Page 19

Gearing

"More Power from Less Space" is title of folder which shows many applications of Spiroid gears in radios, cranes, tractor steering, gear motors, electric food mixers, and winches. Their design and engineer-

ing features are detailed. 8 pages. Illinois Tool Works, Spiroid Gear Div., 2501 N. Keeler Ave., Chicago 39, Ill. J

Circle 584 on Page 19

Selector Switch Assemblies

V3 rotary selector switch assemblies, available with from 1 to 8 switching units and from 2 to 8 detent positions, are illustrated and described in Data Sheet 86b. Uses, ratings, and contact arrangements of various models are given. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 585 on Page 19

Swivel Joints

Ratings, dimensions, and other data on self-aligning swivel joints for piping, steam, water, and other fluids are contained in illustrated catalog 1265. They are suited for pressures to 250 psi and temperatures to 425° F. 4 pages. Barco Mfg. Co., 500-530 N. Hough St., Barrington, Ill. J

Circle 586 on Page 19

Tube Fittings

Sections covering self-flaring, no-flare, and flare type fittings for hydraulic service are included in illustrated Catalog 556. Design, installation, dimentional, and engineering data are included in each section. Size range is ⅛ to 2 in. 28 pages. Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio. G

Circle 587 on Page 19

Adjustable Speed Drives

Ultraflex M magnetic amplifier type, packaged, adjustable speed drive, a static power type unit, is subject of illustrated Brochure EN-65. It is offered in sizes from 1 to 200 hp. Its operation, functions, available forms, and applications are detailed. 12 pages. Cutler-Hammer, Inc., Milwaukee 1, Wis. K

Circle 588 on Page 19

Clutches & Brakes

Specifications, dimensional data, performance curves, and other data on extensive line of subminiature electromagnetic clutches and brakes are found in illustrated Catalog 957A. A 120-configuration selection is offered. 28 pages. Autotronics Inc., Florissant, Mo. I

Circle 589 on Page 19

Heat Resistant Alloy

"Croloy 15-15N, an Austenitic Heat Resistant Alloy for Severe Tubular Application at Elevated Temperatures" is title of Bulletin TR-555, a reprint of a paper which describes the testing program and characteristics of the alloy. Many graphs and photomicrographs are included. 12 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 590 on Page 19

Multipole Switches

Photos and dimensioned drawings, engineering data, electrical ratings, and circuit and contact diagrams for line of rotary multipole switches are content of catalog. Solenoid-operated, instrument,

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The new concept in electronic and instrument packaging, the EMCOR MODULAR ENCLOSURE SYSTEM, is shown in the new CAA air traffic control tower installation, Natrona County Airport, Casper, Wyoming; and a municipal fire control center (Upper) controlling automatic fire recording devices, communications stations and coded alarm signals. EMCOR'S scientific engineering mastery in metal cabinetry makes possible the arrangement of groups of intricately wired instruments, indicators, dials and electronic scopes for easy visual and manual operation while reducing environmental fatigue and strain.

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Circle 466 on Page 19

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Circle 467 on Page 19

and control switches are covered. 20 pages. Electro Switch Corp., Weymouth 88, Mass. B

Circle 591 on Page 19

Meter Mountings

Mountings for meters and instruments on aircraft, combat vehicles, tractors, cranes, power plants, etc., are described and illustrated in Bulletin 601. Complete specifications are given. 4 pages. Lord Mfg. Co., Erie, Pa. F

Circle 592 on Page 19

Expansion Joints

Design Guide 182 for application and selection of Flexon expansion joints covers types of joints, their construction, types of motion, design considerations, selection data, installation, and specifications. Much data are in table and graph form. 28 pages. Flexonics Corp., 1315 S. Third Ave., Maywood, Ill. J

Circle 593 on Page 19

Plastics

Series of case study folders covers uses of various types of plastics in a diverse line of finished products, including packages, bearings, auto parts, printed circuits, textile mill parts, and electrical insulation. 4 pages each. Richardson Co., 2805 Lake St., Melrose Park, Ill. J

Circle 594 on Page 19

Solenoids

Advantages of choosing Double T solenoids, why solenoids are used, and selection of the right solenoid are among subjects covered in illustrated folder. Operating data for various models, including performance curves, are given. 8 pages. Controls Co. of America, 9555 Soreng Ave., Schiller Park, Ill. K

Circle 595 on Page 19

Vertical Motors

Line of vertical hollow shaft motors for powering turbine pumps is detailed in pages of Bulletin MM161. Models from 1 to 700 hp are offered in weather-protected construction and 1 to 500 hp in totally-enclosed and explosionproof constructions. Features are illustrated and specifications are given. 4 pages. A. O. Smith Corp., Electric Motor Div., Tipp City, Ohio. G

Circle 596 on Page 19

Microfilmed Drawings

Simplified drafting, minimum letter heights, and line and background densities for active engineering drawings to be microfilmed, unitized, and reproduced in reduced size by electrostatic printing and offset are discussed in illustrated report. It is entitled "Drafting Standards for Microfilmed Engineering Drawings." 8 pages. Filmsort Co., Pearl River, N. Y. D

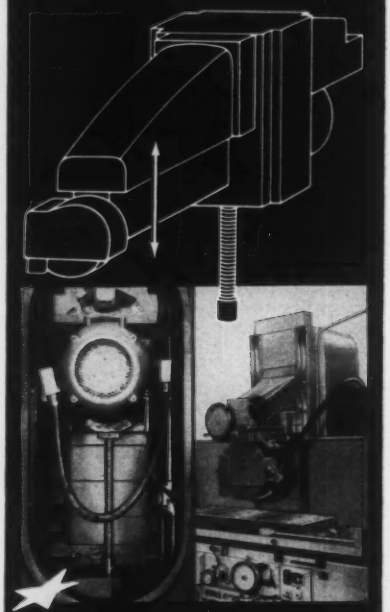
Circle 597 on Page 19

Circuit Breakers

Price, dimensional, and application information on line of molded case and low voltage power circuit breakers, switchgear and unit substations, and high voltage

OPA ★

Gallmeyer & Livingston got it when they changed to a Beaver Ball Screw!



Optimum Positioning Accuracy with system stiffness in the head slide of their Model F surface grinder was the design objective of Gallmeyer & Livingston engineers when they changed from an acme to a ball screw — The other advantages they gained were bonuses!

Does your product require precise control of very small increments of motion? Make use of our extensive engineering and application experience. Write for free catalog.

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 468 on Page 19

devices are presented in 1858 Speedfax catalog. Central selection chart indicates ratings, overcurrent devices, attachments and modifications offered on individually-enclosed breakers. Wiring diagrams are included for each breaker. 56 pages. I-T-E Circuit Breaker Co., 19th & Hamilton Streets, Philadelphia 30, Pa. C

Circle 598 on Page 19

Continuous Hinges

Standard and special types of continuous hinges for aircraft, luggage, instrument, furniture, cabinet, and other uses are described in illustrated folder. Ordering data, specifications are given for hinges of aluminum, steel, stainless steel, and brass. 12 pages. La Deau Mfg. Co., 2702 San Fernando Rd., Los Angeles 65, Calif. L

Circle 599 on Page 19

Teflon Packings, Bearings

Advantages of Teflon for packings, bearings, gaskets, and rings are outlined in Sirvene Materials Bulletin CT-1. Chemical, thermal, mechanical, frictional, and other properties are given. 4 pages. Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago 22, Ill. J

Circle 600 on Page 19

Rotary Selector Switch

Performance data and environmental conditions of the C-80335-001 hermetically sealed, high voltage, rotary selector switch are presented in illustrated Bulletin 158-HV. It is rated at 1650 v dc and 20 ma. 1 page. G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio. G

Circle 601 on Page 19

Welding Design

How a machine tool manufacturer cut manufacturing cost 38 per cent by fabricating a grinder base by arc welding is related in folder "Design Ideas No. 19." Design factors are described. 4 pages. Lincoln Electric Co., Cleveland 17, Ohio. F

Circle 602 on Page 19

Voltage Regulators

Catalog Sheet 1.050 describes precision filament voltage regulators, built around the Regohm to operate from an input of 115 v, ±0.10 per cent. Operating principles are covered. 2 pages. Electric Regulator Corp., Pearl St., Norwalk, Conn. B

Circle 603 on Page 19

Magnetic & Motorized Valves

Specifications of magnetic and motorized valves for use in air, water, gas, steam, oil, and refrigerant service are given in illustrated Catalog V-58. Also included are solenoid coil rating tables and flow charts for liquids and compressible fluids. 24 pages. Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill. J

Circle 604 on Page 19

Product Design

"New Concepts for Product Leadership" is an illustrated brochure on new product design and development containing 24 examples of "p' nned product"

Film strip taken at high speed shows complex movement of thread in outsole stitching machine.

When 1/10 sec. "slowed" to 20 sec.

the secret of the broken thread unfolded

Suppose you designed a machine that operated at 600-800 cycles per minute—and found that something was wrong.

In developing an outsole stitching machine, the Research Division of United Shoe Machinery Corp. of Beverly, Mass., faced the problem of occasional thread breakage from unknown causes. Since the mechanism operated at 600-800 stitches per minute, the problem couldn't possibly be traced by visual inspection.

Engineers found the answer with high speed movies. Using a Kodak High Speed Camera, they were able to film the operation of the stitching machine at 3200 frames per second. When they projected the film at a normal 16 frames per second, the duration of a single stitch, actually 1/10 of a second, was slowed to *20 seconds* on the screen.

The movies clearly showed that thread breakage resulted from dynamic conditions which upset the timing of the cam shaft and associated linkage, and from unsuspected paths of thread motion caused by the operating speed of the machine.

Perhaps you, too, face machine design problems which conventional methods cannot solve. You'll find the answers quickly and at a minimum cost of time, money, and manpower—with high speed movies.

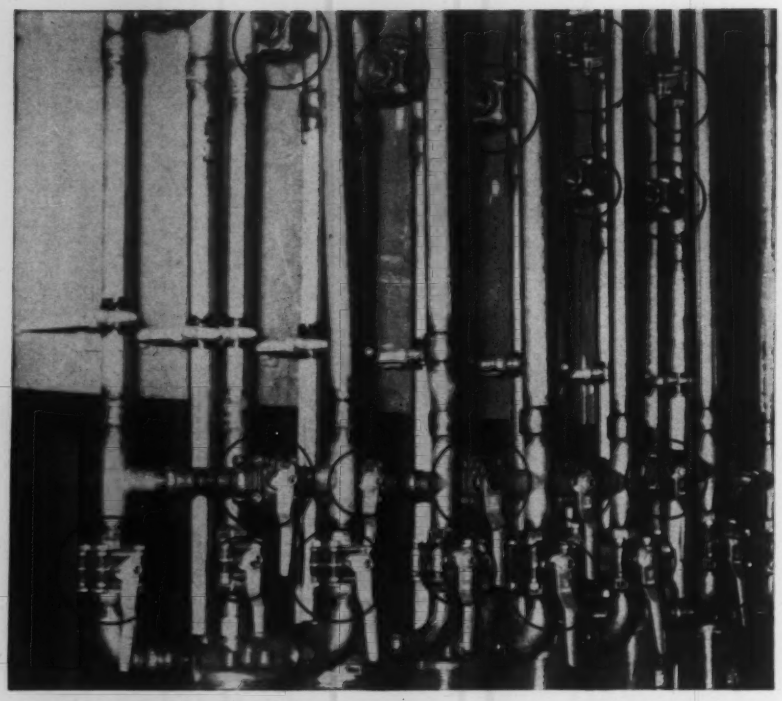
For complete details send for the free booklet, "High Speed Motion Pictures at the Service of the Engineer."

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the Kodak *HIGH SPEED* Camera

Kodak
TRADE MARK

Circle 469 on Page 19

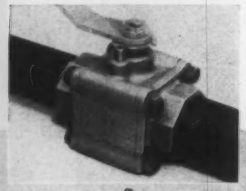


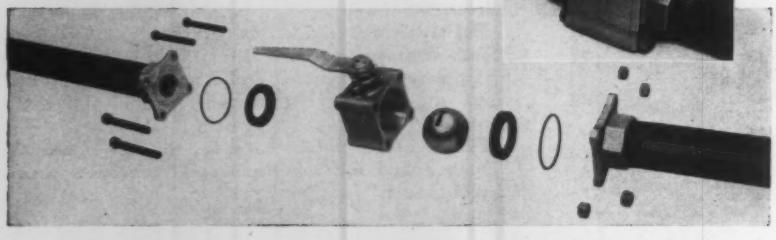
Only the ECON-O-"MISER" Ball Valve was able to solve this problem for PathéColor, Inc.

THE PROBLEM: To find a valve that would meet all of the following requirements:

1. Quick visual indication of position and quarter turn operation. 2. Excellent flow characteristics and positive shut-off. 3. The advantages of flange construction without the bulk and weight of conventional flanged valves. 4. Easy & quick disassembling for low cost maintenance. 5. The most compact and economical installation of Type 316 stainless steel valves possible.

SOLUTION: *Specifying* and *installing* Worcester's Econ-o-"miser" Ball Valve. In so doing PathéColor found a valve that provides a positive seal, a flanged construction much more compact than conventional valves that could be socket welded. In addition many unions and companion flanges were eliminated with the overall result that savings on this installation alone amounted to many hundreds of dollars.





Valves available, ¼"-2", in following standard materials*: Bronze, Aluminum Bronze, Aluminum, Carbon Steel and Types 303 and 316 Stainless Steel. Standard Seat and O-Ring materials*: Buna-N, Neoprene, and Teflon.

**Other materials available on request.*

For further information and descriptive literature write to:

WORCESTER VALVE CO., INC.

16 PARKER STREET • WORCESTER, MASS.

Circle 470 on Page 19

developmental techniques. The problem, solution, and new design concepts used are detailed for a diverse line of products. 20 pages. Designers for Industry, 4241 Fulton Parkway, Cleveland 9, Ohio. G

Circle 605 on Page 19

Hard Surfacing

Engineering Data Sheet No. 21 is descriptive of Colmonoy No. 75, a new tungsten carbide Sprayweld powder. It covers the content, properties, and typical applications of this hard surfacing material. Base metal and overlay recommendations are included. 2 pages. Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich. H

Circle 606 on Page 19

Flexible Drive Couplings

Details of the new Series A press-on and Series B interchangeable hub type Magnaloy flexible drive couplings are presented in illustrated bulletin. They are available for shaft sizes from ⅜ to 6 in. for delivering up to 45.6 hp per 100 rpm. 4 pages. Detroit Power Coupling Co., 992 W. Seven Mile Rd., Detroit 3, Mich. H

Circle 607 on Page 19

Liquid Level Controls

Concise selection guidance as well as complete specifications and performance data on the ECA line of liquid level controls are contained in Bulletin PF 571. Both electronic and electromagnetic types are available, and they can be used in practically all liquids. 16 pages. Electronics Corp. of America, Photoswitch Div., 1 Memorial Dr., Cambridge, Mass. B

Circle 608 on Page 19

Metal-Ceramics

New metal-ceramics that show definite promise in the area of high-temperature service where most metals or ceramics alone fail are subject of illustrated technical guidebook. It explains the physical, mechanical, and chemical properties, as well as typical applications of these new cermets which are now in use at temperatures up to 2800° F. Haynes Stellite Co., Kokomo, Ind. C

Circle 609 on Page 19

Roller Chain Drives

Prepared for designers and production engineers concerned with drives, Catalog D-58 contains complete descriptions, prices, and tabular data on roller chain drives. Featured items include bushed and plate type sprockets, interchangeable bushings, and single and double strand roller chain. 8 pages. Maurey Mfg. Corp., 2915 S. Wabash Ave., Chicago 16, Ill. J

Circle 610 on Page 19

Gear Production

In addition to detailing the wide variety of gears, power transmission components, precision machined parts, and engineering service offered by this company, "Facts and Figures" bulletin describes company facilities for contract

manufacturing in the above fields. 10 pages. Geartronics Corp., 50 Nashua St., Woburn, Mass. B

Circle 611 on Page 19

Lead-Bearing Bars

Chemical composition, physical and chemical properties, and other data on USS Amer-Led steels are presented in Bulletin 6659. These lead-bearing free-machining cold-finished bars offer cost reduction and production increases, some of which are covered in case histories in this bulletin. 8 pages. United States Steel Corp., American Steel & Wire Div., Rockefeller Bldg., Cleveland 13, Ohio. F

Circle 612 on Page 19

Mechanisms & Components

Bulletin 102-58 describes a complete line of predesigned mechanisms and components for the servo and instruments fields. An unlimited variety of geared mechanisms for use in breadboarding, prototype, and production applications are covered. 6 pages. Precision Mechanisms Corp., 577 Newbridge Ave., East Meadow, N. Y. D

Circle 613 on Page 19

Plastics Products

The product development, mold design, quality control, tooling, and various production steps that go into the compression and injection molding of plastic products are described in illustrated brochure. Finishing, assembly, and decoration are covered. 20 pages. Request on company letterhead from Consolidated Molded Products Corp., 333 Cherry St., Scranton 2, Pa. E

Aluminum in Cooling Systems

A study of corrosion of aluminum in automotive cooling systems is contained in illustrated report. It shows that high chloride content water causes severe top tank corrosion. Effect of corrosion inhibitors is related. 8 pages. Request directly from E. I. du Pont de Nemours & Co., Room 8165-D, Wilmington 98, Del. C

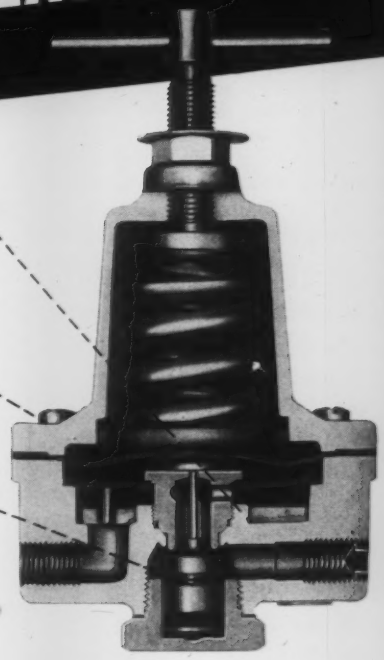
Cold Roll Forming

"Cold Roll Forming" reference manual tells how to produce a variety of metal shapes by this method. Special operations involving tubular, structural, and ornamental formed shapes are also covered. Curving, coiling, ring-forming, notching, perforating, welding, and embossing are explained. 88 pages. Write to Yoder Co., 5500 Walworth Ave., Cleveland 2, Ohio. G

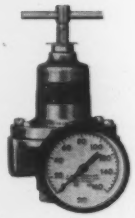
Hydraulic Presses

Range of presses for producing laminated plastics, pressing dry ice, die hobbing, preforming, and plastics and metal-powder compacting are described in Bulletin 3300. It furnishes conversion tables, ram capacities, sheet metal gages, steel pipe tables, specific gravities and materials strength figures. 40 pages. Write on company letterhead to Baldwin-Lima-Hamilton Corp., Hamilton Div., Hamilton, Ohio. G

NEW... Norgren
WATER PRESSURE REGULATORS



LOW COST... Plus LONG, TROUBLE-FREE SERVICE



- The NEW Norgren Water Pressure Regulators provide accurate regulation of pressure even with widely fluctuating line pressure and rapidly varying flow. Line pressures up to 400 psi are reduced to working pressures up to 250 psi.
- All parts in contact with water are designed to give maximum protection against corrosion.
- For ¼", ⅜", ½", ¾" and 1" pipe sizes.

For complete information, call your nearby Norgren Representative listed in your telephone directory . . . or **WRITE FOR DESCRIPTIVE FORM 910**

If it's Norgren...It's Dependable.

C. A. NORGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

Circle 471 on Page 19

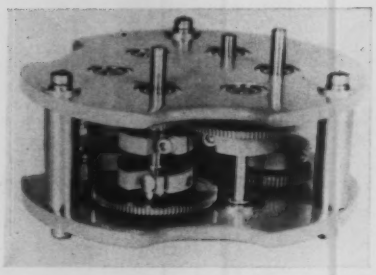
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Gear Box

for use in servo and instrument equipment

New adaptable gear box provides a choice of gear reductions from 1:1 to 3125:1. Unit can be assembled in an almost unlimited number of gearing configurations from shafts, gears, antibacklash gears, and slip clutches. Standard shafts provide extensions on both sides and at any of the intermediate gear passes. For



use in servo and instrument equipment, unit is anodized aluminum alloy and stainless steel, and meets requirements of MIL-E-5400. Diameter is 2.875 in., length, 1.090 in. Gears are AGMA Precision 1 or better, and ball bearings are ABEC 7 double shielded. Zero backlash is available in all ratios. **Precision Mechanisms Corp.**, 577 Newbridge Ave., East Meadow, N. Y. D

Circle 614 on Page 19

Flexible Couplings

are miniature units for close-tolerance uses

Six sizes of miniature flexible couplings eliminate backlash and transmit uniform angular velocity at high speeds. For use in close-tolerance applications, they are available in phosphor bronze and beryllium copper. Hydraulically formed seamless metal bellows is employed to reduce bearing wear and excessive friction caused by misalignment of

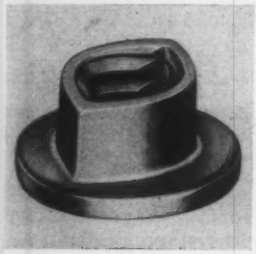
shafts. Couplings can also be used effectively to dampen vibrations. Shaft sizes range from 1/8 to 5/16 in., with over-all lengths from 57/64 to 1 3/32 in. **Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co.**, Milford, Conn. B

Circle 615 on Page 19

Self-Locking Nut

has two integral wrenching points

H50 miniature self-locking nut eliminates conventional hex wrenching surfaces. Two integral wrenching points permit wrenching on threaded nut element itself. This allows installation with standard spin-type or socket wrenches three to four sizes smaller than needed for standard hex nuts. Bearing flange of the nut eliminates tilting in wrench socket, and makes for more rapid engagement of mating bolt. Nut is available in thread sizes No. 4-40, 6-32, and 8-32. It is heat-treated carbon steel for temperatures to 550 F. A nut of A-286 corrosion-resistant steel, designated H52, is also available for nonmagnetic, corrosion-resistant steel applications. **Kaynar Mfg. Co. Inc.**, Box 2001, Terminal Annex, Los Angeles 54, Calif. L

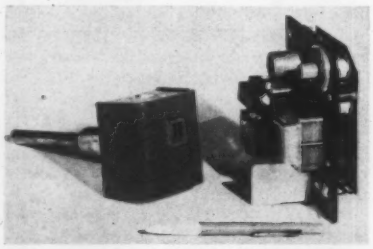


Circle 616 on Page 19

Amplifier Relay System

transistorized unit is for remote control of temperatures

New transistorized - amplifier relay system consists of a compact transistorized amplifier (right), which serves as the temperature controller, and a vibrationproof mounting containing a thermistor sensing element. Thermistor mounting and amplifier relay can be located up to two miles apart. System, providing remote control of temperatures in industrial applications, can be used to control air, surface, or immersion temperatures. Amplifier relays are available in eight overlapping ranges of approximately 100 F to permit control from −60 to 520 F. One amplifier relay can be used



with a variety of heat-sensing units. **Control Device Div., Minneapolis-Honeywell Regulator Co.**, 2747 Fourth Ave. S., Minneapolis, Minn. J

Circle 617 on Page 19

Miniature Air Components

have standard 1/8-27 taper pipe threads

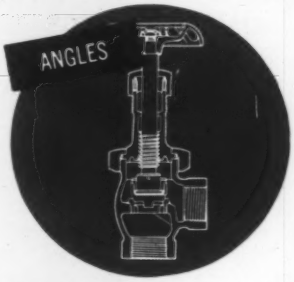
Line of miniaturized air cylinders, valves, and fittings provides almost unlimited adaptation to applications

IF YOUR PRODUCT IS VALVE-EQUIPPED—
JENKINS VALVES WILL ADD AN

Extra Sales Feature

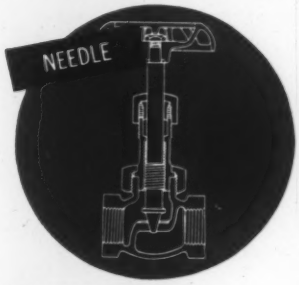
PACKAGE BOILERS • FIRE FIGHTING APPARATUS

LAUNDRY EQUIPMENT • DISH-WASHING MACHINES



STERILIZERS • PROCESSING EQUIPMENT UNITS

CLEANSING EQUIPMENT • HEATING UNITS



COFFEE URNS • PUMPS AND COMPRESSORS

Here's why—

You gain for your product the prestige of Jenkins Valves built by Jenkins continuous advertising in *Fortune, Business Week* and 25 other publications covering every valve-using industry.

You get the extra sales advantage of Jenkins famous Diamond and Signature trademark which identifies each valve.

-and here's how YOU SAVE TIME AND TROUBLE

You profit by Jenkins long experience in supplying valves for all types of products.

You add the valve know-how of Jenkins Engineers to your own designing skill. Modifications of standard valves, such as special handwheels, etc., can be provided when required. Send coupon today for information.

Give your product, and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.* Jenkins Bros., 100 Park Ave., New York 17.

SOLD THROUGH
LEADING INDUSTRIAL DISTRIBUTORS

JENKINS VALVES

LOOK FOR THE DIAMOND MARK

SINCE 1864

TRADE JENKINS MARK

Jenkins Bros.

JENKINS BROS., 100 Park Ave., New York

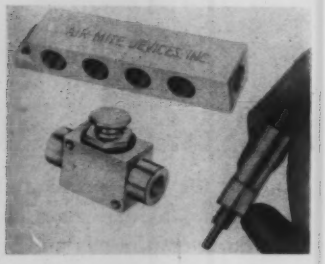
Send Catalog No. 56

Name_____

Company_____

Address_____

Circle 472 on Page 19



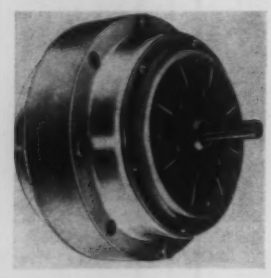
requiring high-cycle opening, closing, holding, ejecting, marking, centering, and counting. All components have standard 1/8-27 taper pipe threads. Single-acting, spring-return cylinder with 3/8-in. bore and 1/2-in. stroke, is machined from solid hexagon aluminum bar stock. Cylinder design permits quick, easy replacement of packing. Three-way, normally closed valve is fabricated as an assembly, assuring easy accessibility when necessary to service valve or replace packings. Servicing valve does not necessitate removal of unit from the line. Eight-port manifold, which permits multiple miniaturized cylinder actuations from a single source, has large air passages for efficient operation. Miniature fittings, connections, reducers, brackets, and hose are also available to permit assembly of a complete miniaturized power package. **Air-Mite Devices Inc.**, 4401 W. Kinzie St., Chicago 24, Ill. I

Circle 618 on Page 19

Miniature Motor

in 1/200 to 1/20-hp ratings

Subfractional-horsepower hysteresis motor has heat rise of only 20 to 38 C, depending on horsepower rating. Ratings are from 1/200 to 1/20 hp, with running torques of



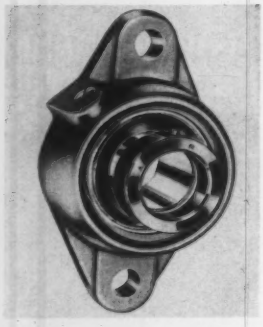
2.8 to 28 oz-in. Motor reaches full speed in one revolution and maintains synchronous speed at rated load. It is totally encased for complete protection against environment. Motor is smooth running, with no vibration or magnetic strays. It is suited for applications such as facsimile machines, phonograph turntables, tape recorders, telemetering, and other uses where constant synchronous speed is essential. **Dale Products Inc.**, Columbus, Neb. I

Circle 619 on Page 19

Ball-Bearing Mount

is flange-cartridge type

New flange-cartridge ball-bearing mount for confined spaces is adequate for heavy-duty service. Ball bearing's wide inner ring is self-aligning in any position, and accommodates shaft diameters from 1/2 to 1-15/16 in. Housing flange has two bolts instead of standard four. The two-bolt flange cartridge is available with two types of seals,



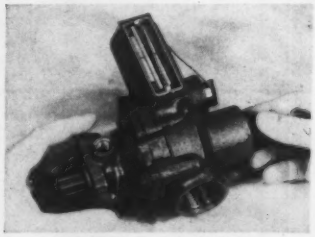
both of which keep lubricants in and foreign matter out. Contact-type seals, for slow to moderate speeds, provide extra protection against contaminants. **Fafnir Bearing Co.**, New Britain, Conn. B

Circle 620 on Page 19

Gear Pump

variable-displacement unit has only two major moving parts

New VIEP variable-displacement gear pump features automatic pressure compensation and contains only two major moving parts. Pump, designed for use in airborne hydraulic systems, is also applicable in industrial machinery and equipment, particularly in high-speed, high-temperature operations. Main pumping elements consist of an internal ring gear and pinion. Integral pressure-sensing device provides automatic pressure compensation, adjusting pump displacement to meet variations in system delivery requirements. Gear set alignment is maintained independent of hydraulic loads or thermal conditions. A 270-deg inlet area provides positive filling and eliminates inlet pressurization at speeds to 24,000 rpm. Pump is available for operation at



temperatures to 500 F, deliveries to 80 gpm, and pressures to 3000 psi. **Pesco Products Div., Borg-Warner Corp.**, 24700 N. Miles Rd., Bedford, Ohio. G

Circle 621 on Page 19

Titanium Alloys

heat treat to high strength-weight ratios

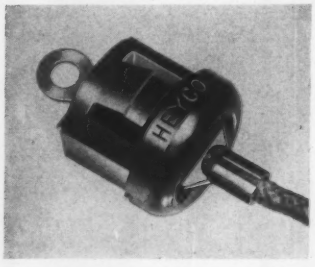
Three new titanium alloys are capable of being formed readily in soft condition and then strengthened by thermal aging treatments. Strengths obtainable are higher than in previous titanium sheet materials. B120VCA, new beta alloy, can be heat treated to 240,000 psi minimum tensile strength, and is cold-headable. The other two alloys, designated C115AMoV and C105VA, have a combined alpha-beta structure which must be quenched to retain beta phase. Corrosion resistance of the alloys is excellent. They are expected to have many applications in aircraft and missiles. **Crucible Steel Co. of America**, Oliver Bldg., Pittsburgh 22, Pa. F

Circle 622 on Page 19

Junction-Terminal Bushing

has miniature, insulated nylon body

Heyco Snap-In junction-terminal bushing is a miniature nylon insulated receptacle to which quick



MB-designed vibration test systems give

high performance table motion

It's *System Performance* that counts most in vibration testing.

Whole purpose of a vibration test system, large or little, is to subject specimens to *motions* that simulate service conditions as closely as possible. Such motion gives you *reliable* information on vibratory response and performance of structures, products, components. It helps reduce risk of malfunction or failures in the field.

But many factors contribute to this motion. Among them: force output and characteristics of the exciter; ample and undistorted power supply to meet all shaker-plus-specimen load relationships; meticulous matching of components in the entire system from input signal to output at the shaker table.

INTEGRATED SYSTEM OFFERS OPTIMUM RESULTS

As the manufacturer of *complete* systems, MB intimately knows the operational needs of shaker, builds amplifiers and controls around those needs. Each MB system is integrated toward the highly desired end result . . . *delivering optimum performance at the shaker table* for present and future needs.

The largest field service organization in vibration testing is ready to help you achieve that result. For latest information, call on MB.

HIGH FORCE HIGH PERFORMANCE SYSTEM

Shown above is a typical MB test system. It includes a Model C70 7000 pound force vibration exciter fit for environmental testing chambers.

The MB T996 amplifier is rated at 50KVA output and can handle the most adverse reactive shaker loads for broad-band sine wave and random motion testing. The T68MC control console is easy to use, also provides automatically cycled testing. The T88 console expands system for complex motion work.

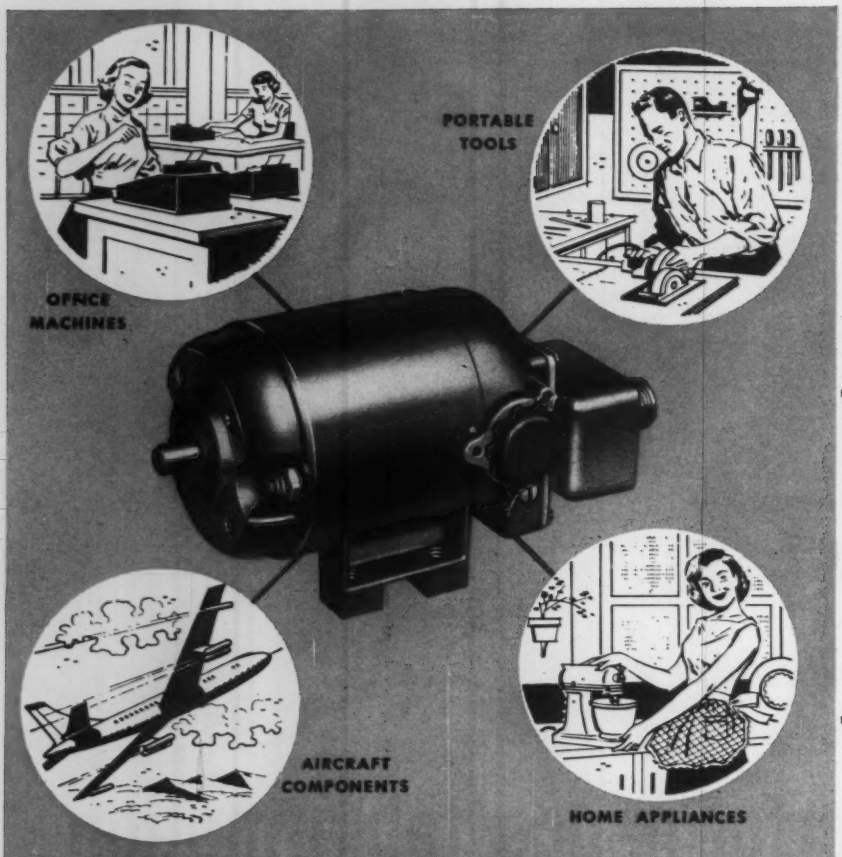
Send for Bulletin 470 which gives detailed specifications on the high performance available from this system; and from others to 25,000 pounds force.

largest producer of complete systems for vibration testing

MB manufacturing company 1056 State Street New Haven 11, Conn.

A Division of Textron Inc.

Circle 473 on Page 19



Small Motor... BIG Idea

FOR YOUR MOTOR-DRIVEN PRODUCT

This motor is representative of the many Lamb Electric motors *specially engineered* to provide:

(1) the dependable power and smooth, efficient operation required for top product *performance.*

(2) the low weight and compactness required for easy portability and good product *appearance.*

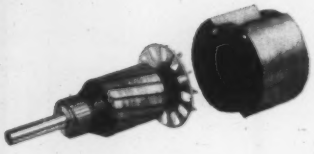
These advantages are standard with Lamb Electric Motors, at no increase in cost, because our plant is equipped and organized to *custom manufacture on a volume basis.* May we demonstrate?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

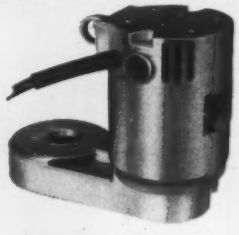
A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

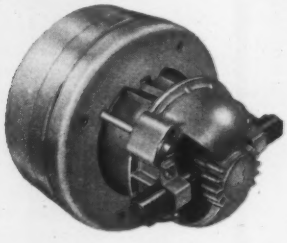
Circuit breaker actuator motor.



Motor parts for portable electric tools.



Impact concrete drill motor.



Turbine for canister-type vacuum cleaner.

Lamb Electric

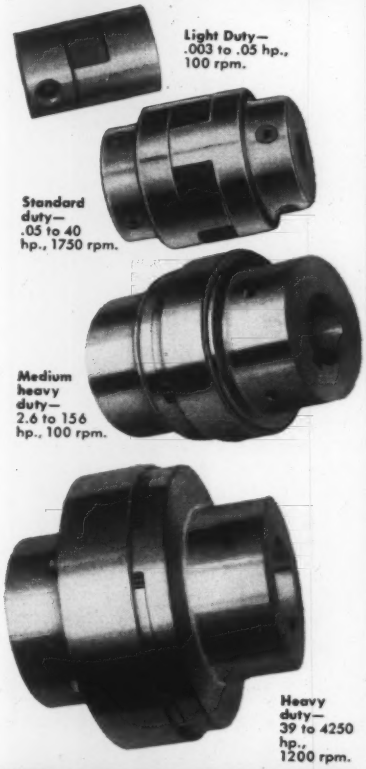
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

If you are interested in any of the above motors write and we shall be glad to send full information.

Circle 474 on Page 19

Lovejoy

Flexible Couplings



from .003 to 4250 H.P.
⅛ In. to over 9½ In. Bores

- Can be installed in minutes
- Align with a straight edge—no gauges required

The most trouble-free couplings you can install on your equipment . . . no complicated mechanisms, all parts open for inspection, reversible cushions, no lubrication required. Immediate delivery from stock in any quantity.

Send us your requirements for quick recommendations and prices. Ask about our helpful Flexible Coupling Guide Sheet and request Catalog C-56.

Lovejoy

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LOVEJOY FLEXIBLE COUPLING CO.

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Telephone: ESTebrook 9-3010

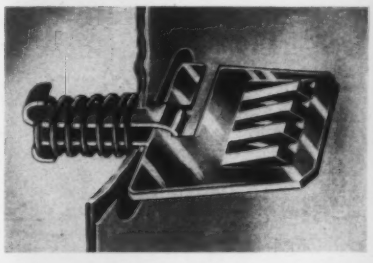
Circle 475 on Page 19

connect or disconnect is easily accomplished with standard 3/16-in. female terminals. Bushing eliminates pig-tail wire leads, screw terminals, and junction blocks. Three types of brass terminals are available: Solder, crimp, and double disconnect. Wire is fastened to permanent end of terminals and terminal is snap-fastened into nylon receptacle. Color-coded terminal bushing is then snap-anchored into chassis hole. Blue, green, yellow, white, black, red, and brown colors are available. **Heyman Mfg. Co.**, Kenilworth, N. J. D

Circle 623 on Page 19

Fastener

for attachment and removal of sheet-metal parts



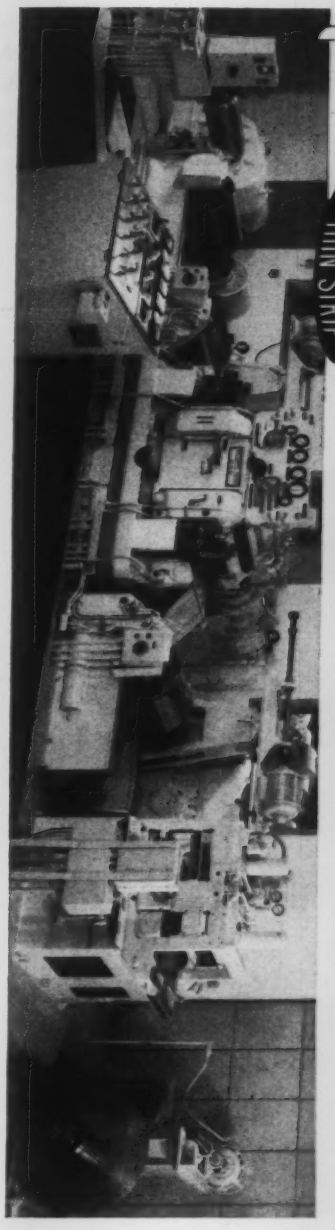
Lite-Lok fastener, consisting of tab, yoke, and spring, is easily installed in thicknesses to 5/32 in. and is applicable where two or more sheet-metal parts require quick attachment and removal. It eliminates need for thumbscrews. Decorative serrations on tab permit easy gripping to release for removal. **Southco Div., South Chester Corp.**, Lester, Pa. E

Circle 624 on Page 19

Power Supply

miniature unit supplies 60 ma at 300 v dc

New power supply occupies 5 cu in. and weighs 5½ oz. It supplies 60 ma or more current at 300 v dc from 115-v 400-cycle ac input source. Unit meets MIL-T-5422C, and has a variety of airborne and ground applications. High operating efficiency results in almost no internal heat dissipation. Output voltage ripple is less than 5 per cent at full output rating. Silicon diodes and paper capacitors provide dependability and long life. Plug-in



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Pure Nickel, Monel, Inconel and Inconel "X" are produced in gauges from .0001" to .020". Stainless Steel, electrolytic Copper and its alloys, such as Brass, Nickel Silver and Phosphor Bronze from .0001" to .010".

For a complete survey of your strip problems at no cost or obligation, write for field engineer or Confidential Data Blank.

Somers Brass Company, Inc.
120 Baldwin Ave. Waterbury, Conn.

Circle 476 on Page 19

20% Stronger GEAR TRAINS

with OHIO 20° P.A. Gears

You can add as much as 20% more strength to the gearing in your product, simply by switching to OHIO 20° pressure angle gears.

Ohio offers the only complete line of 20° P.A. gears which have exactly the same face width as the older standard 14½° P.A. type.

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20° pressure angle gears are stronger because they have a thicker tooth profile with less undercut. For full information on OHIO's 20° pressure angle gears, call your local OHIO distributor or write OHIO GEAR direct.

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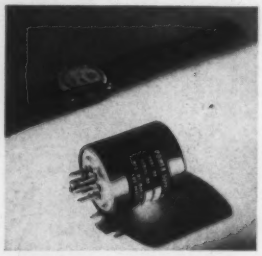
Circle 477 on Page 19



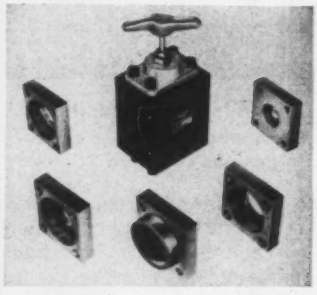
base permits easy electrical connection and mounting. **Master Specialties Co.**, 956 E. 108th St., Los Angeles 59, Calif. L

Circle 625 on Page 19

Throttling Valve Body

with 13 interchangeable port-flanges

Basic 2-in. valve body accommodates any combination of 13 interchangeable port-flanges, attached by set screws. Five types of port-flanges, four of which are available in three line sizes for 1¼, 1½, and 2-in. piping, provide valve flexibility. Available are port-flanges for threaded pipe, one-piece welded pipe, two-piece welded pipe, a straight-thread pipe with boss gasket and seal, and a 1¼-in. twelve-thread Aminco type. Valve meets JIC standards and is available for operating pressures to 7500 psi in light-weight



aluminum body and 10,000 psi in stainless-steel body. **Products Div., Greer Hydraulics Inc.**, New York International Airport, Jamaica 30, N. Y. D

Circle 626 on Page 19

Sealing Washer

in screw or bolt sizes to ½ in. diam

Bartite sealing washer is partially dome shaped, and has a measured amount of sealing compound adhered to the underside. It is available

creative designing calls for an open mind

Leonardo Da Vinci's design for a pump using the Archimedian screw principle

Model courtesy of IBM

EVEN DA VINCI'S DESIGN FOR A PUMP COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

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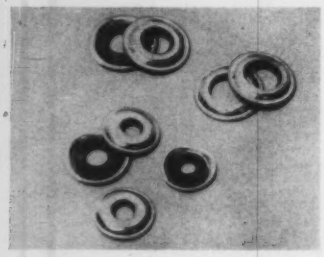
Circle 479 on Page 19

in mild steel and high-carbon steel, heat treated, as well as stainless steel and other metals and finishes. When pressure is applied, dome compresses, forcing sealant to flow downward, outward, and upward to make a complete seal. Sealing compound is stable and nonaging, and withstands temperatures from −100 to 250 F without change. Applications



include automotive, truck, trailer, boat and aircraft building, as well as a variety of original equipment manufacturing. Washer is available in all standard screw or bolt sizes through ½ in. diam. **L. J. Barwood Mfg. Co. Inc.**, 28 Williams St., Everett 49, Mass. B

Circle 627 on Page 19

O-Ring Compounds

have low compression set at high temperatures

Two new O-ring compounds have low compression set at high temperatures, low volume change, and resistance to a variety of destructive chemicals, exotic fuels, synthetic lubricants, and hydraulic fluids. Compound 17007 fills special needs in industry and military services. Service temperature range is −45 to 500 F. Compound 17107 meets most severe military service requirements for resilient elastomers. **Precision Rubber Products Corp.**, 3113 Oakridge Ave., Dayton 17, Ohio. G

Circle 628 on Page 19

Split-Contact Switch

provides two functions in one unit

Type S29-O1A split-contact switch features one common ground, one normally closed and two normally open terminals. It provides multiple-circuit switching at low cost. Unit is available with variations in terminals, electrical rating, actuator

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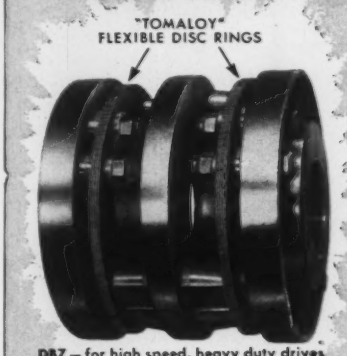
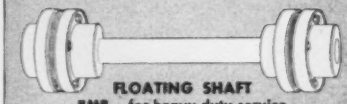
THOMAS
ALL METAL
FLEXIBLE COUPLINGS
FOR MAINTENANCE FREE POWER TRANSMISSION on PUMP, COMPRESSOR, MARINE and OTHER DRIVES

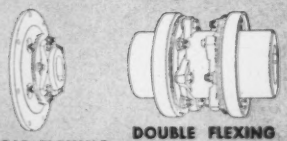


DBZ — for high speed, heavy duty drives

Thomas' 40 years of flexible coupling experience is at your disposal to help you meet ordinary applications or special variations for unusual cases.



FLOATING SHAFT
BMR — for heavy duty service with excessive misalignment



SINGLE FLEXING
SS — for engine-driven generator sets with out-board bearings

DOUBLE FLEXING
AMR — for engine and medium speed drives

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
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6 No Lubrication
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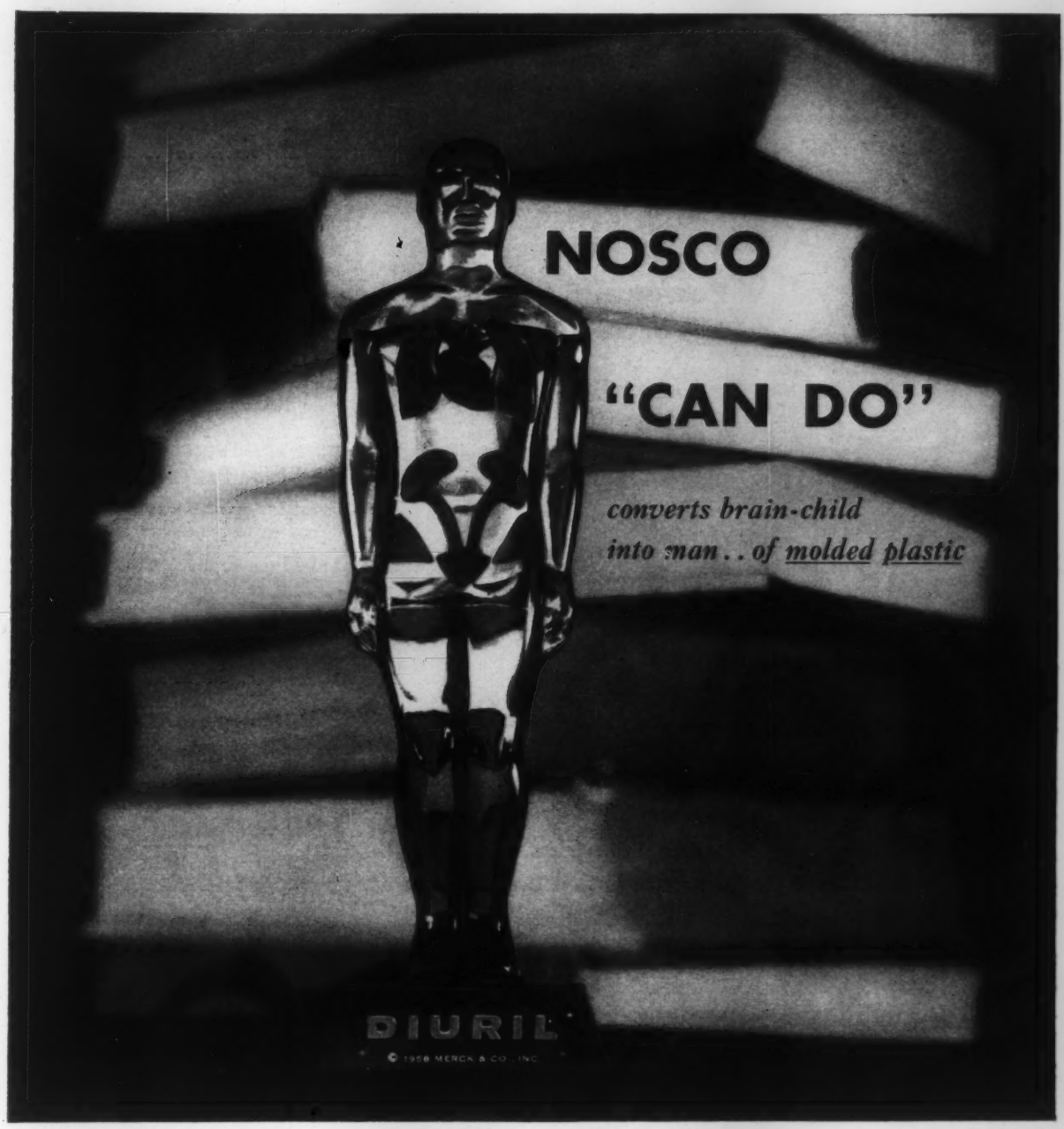
Circle 480 on Page 19



This was the brain-child of Merck Sharp & Dohme, pharmaceutical manufacturer. They showed Nosco a sketch and said "Make us a man, six inches tall; a small plastic figure to introduce doctors to 'DIURIL,' a new drug which controls the body's fluid content." The figure had to be fluid-filled and transparent to show the internal organs.

How did Nosco "Can Do" make a man? First we built a prototype by hand, then refined the design many times to facilitate volume production. The figurine is molded of cellulose propionate plastic in a Nosco-designed, two-unit mold. Each finished figure contains five parts. Nosco's finishing department painted the tiny heart, lungs and kidneys, hot-stamped the trade name, cemented the internal organs, assembled the front and back body sections, filled the figure with fluid to a pre-specified level, cemented the plug in place, packed both individual and shipping cartons . . . and we had our man! *Rate of assembly: 3000 per shift!*

The toughest part of Nosco's job was to prevent leakage. Here's how successful we were: Nosco quality control delivered over 99.9% non-leaking, *perfect* pieces. Nosco likes tough jobs . . . likes to turn *your* brain-child into reality in practical plastics. For more information about Nosco "Can Do," just write or call.

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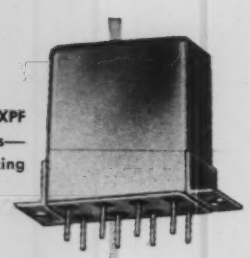
Circle 481 on Page 19



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0.2" grid spacing

Actual size photos

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✓Power and Low Level Switching

✓30 G Vibration AT 2000 CYCLES

FC-2-XLF
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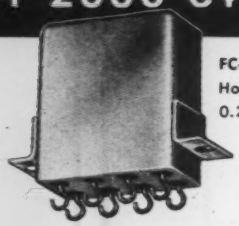
0.2" grid spacing



FC-2-XHF
Hook leads—
0.2" grid spacing

NEW! FC-2 DC RELAYS

Subminiature, hermetically-sealed types

These new FC-2 types are the latest development in high reliability missile relays — designed and produced by Struthers-Dunn, the pioneers in miniature, hermetically-sealed relays.

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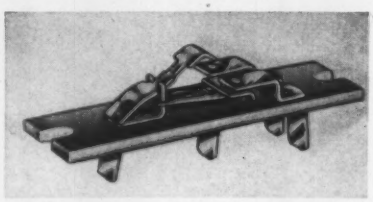


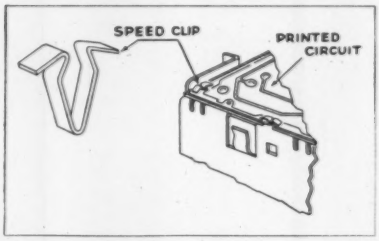
designs, contact arrangements, and mounting panels. Unit illustrated is 2½ in. long, 3¼ in. wide, and 1 in. high. It is rated 5 amp, 125 v ac, normally open, and 10 amp, 125 v ac, normally closed. **Cherry Electrical Products Corp.**, 1650 Deerfield Rd., Highland Park, Ill. I

Circle 629 on Page 19

Dart-Type Fastener

retains printed-circuit boards to panels

Dual-functioning, dart-type Speed Clip of heat-treated spring steel retains circuit boards to panels and provides a positive electrical ground at points where it is inserted around the circuitry. Spring resiliency of clip legs provides sufficient give to prevent circuit board from cracking with twisting or racking of chassis. Resiliency also prevents intermit-



tent grounding or loosening by vibration, even under severe conditions. **Tinnerman Products Inc.**, P. O. Box 6688, Cleveland, Ohio. F

Circle 630 on Page 19

Vacuum-Melted Alloy

for high-strength, high-temperature use

W-545 consumable-arc vacuum-melted alloy is composed of iron, nickel, chromium, molybdenum, titanium, and manganese. It is for high-strength applications at temperatures to 1350 F. Alloy is easily fabricated for use in high-stressed parts such as turbine wheels, couplings, shafts, valve stems, and bolts in missiles, and gas or steam tur-

Circle 482 on Page 19

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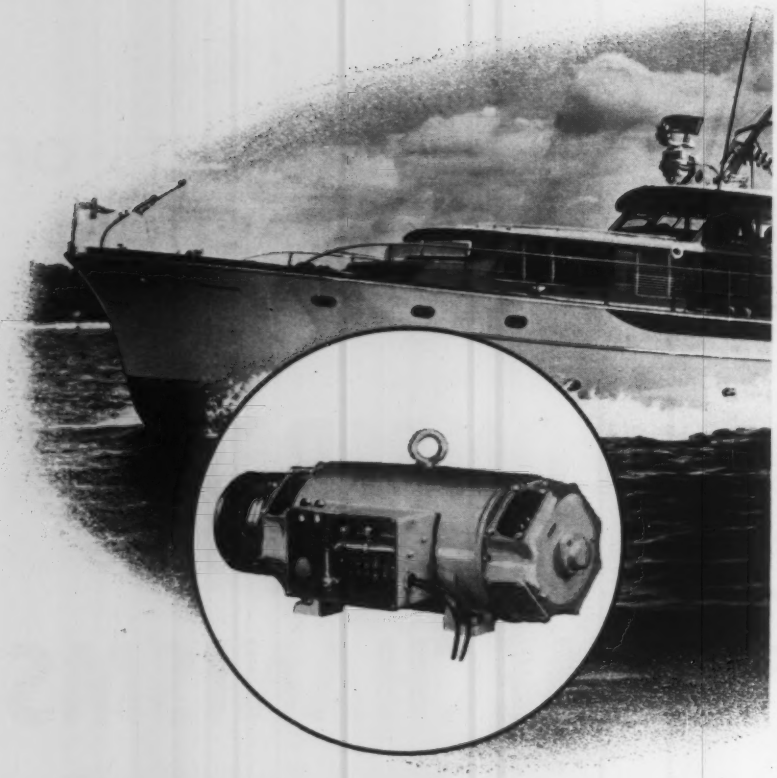


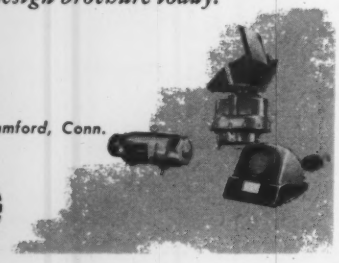
ESCO alternator powers new ultra-compact high-performance radar

Based on an entirely new concept in radar design, this Raytheon "Mariners Pathfinder" radar is compact enough for use on the most modest pleasure cruiser, yet big enough in performance for the largest commercial vessels. Utilizing just two, simple units, it provides clear, steady displays up to 16 miles range. Rugged and reliable, it's real sea-going equipment, built to operate in slashing northeasters, arctic ice and the heat and humidity of tropic seas.

To provide a source of dependable, stable power for the "Mariners Pathfinder", Raytheon chose a specially-designed ESCO motor-alternator. Operating from a 32V, 110V or 220V DC ship's supply, this built-to-order inverter delivers a 115V 60-cycle AC output, regulated to ±3V and ±0.6 cycles over a 20% variation in input voltage. It's designed for a minimum of 10,000 hours trouble-free operation under extremely wide variations in temperature, humidity, and pitch and roll conditions.

Building special rotating electrical equipment to meet individual requirements has been a specialty at ESCO for almost half a century. Why not call on ESCO for the ideal generator or motor for your equipment, too? *Write for design brochure today.*

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.



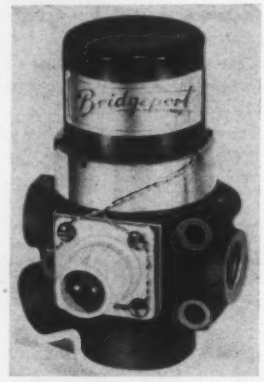
Circle 484 on Page 19

bines. Nonmagnetic and high yield strength characteristics make it useful for low-temperature applications such as retaining rings and wedges for electrical apparatus. Alloy is available in forged rough-turned billets to 10-in. diam, upset pancake forgings to about 1000 lb, round, centerless ground bar in all sizes, cold-rolled strip in continuous lengths 18 in. wide or less in thicknesses from 0.005 to 0.090 in., and in plate from ⅛ to 3 in. thick and up to 18 in. wide. Alloy forges well between temperatures of 1700 and 2100 F. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa. F

Circle 631 on Page 19

High-Pressure Valve

handles pressures over 3000 psi



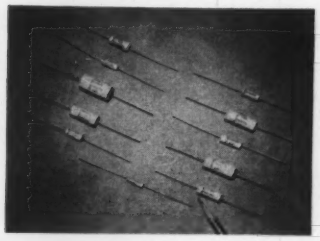
Model 65M44 three-way, solenoid-operated aircraft valve measures 3.4 x 2.07 x 2.095 in. and weighs only 0.77 lb. It handles pressures in excess of 3000 psi. The ¼-in. valve is suitable for use with various gases, liquids including fuels and oils, and certain corrosive materials in a temperature range beyond 350 F. Captive seal floats between valve seat and poppet to maintain perfect balance, regardless of pressure. **Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co.**, Milford, Conn. B

Circle 632 on Page 19

Capacitors

for blocking, filter, and by-pass applications

Lectrofilm-B dielectric capacitors are fixed and enclosed in nonmetal-



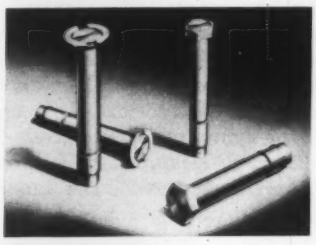
lic cases for blocking, filter, and bypass applications where low failure rates and long life are of primary importance. They are particularly suitable for applications in missiles, computers, business machines, mobile communications equipment, and other electronic applications. Capacitance values are available from 0.001 to 0.68 uf, with tolerances of 5, 10, and 20 per cent. Voltage ratings are 100 to 600 v dc from −55 to 85 C, and 50 to 400 v dc from −55 to 125 C. Unit size ranges from 0.111-in. diam by 0.75-in. long, to 0.562-in. diam by 1.34-in. long. **Capacitor Dept., General Electric Co.,** Hudson Falls, N. Y. C

Circle 633 on Page 19

Blind Fastener

is removable and reusable

Sleev-Lock blind-type fastener can be inserted, tightened, and later removed from one side of a panel with an inexpensive power-tool attachment. Two available configurations —the 100-deg flush-head type (left) and the hex-head protruding type (right)—each consist of an outer sleeve, nut, and inner core bolt, all preassembled in a single unit. Driving attachment holds outer sleeve stationary in hole while core bolt pulls nut up over knurled end of sleeve. Sleeve and core bolt can be removed and reused after reversing drive to drop nut off other end. Shear values range from 95,000 psi, depending on material. Fastener is available in titanium, heat-resistant stainless, and high-strength alloy steels. Sizes range from 3/16



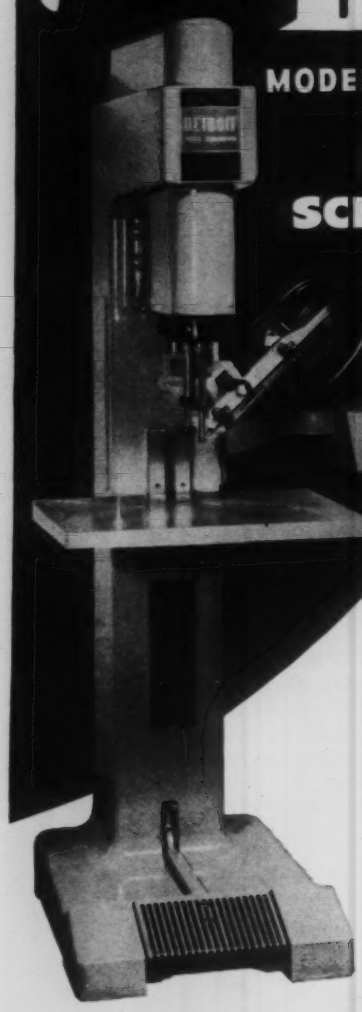
MEMO
TO H. R.
FROM V. L.
Are we using the field engineer from UNION CHAIN? He can help us.
He certainly can. He represents a company that makes all types of steel drive and conveying chain plus sprockets and attachments. His engineering experience is therefore broad. He is familiar with, or able to comprehend, the problems involved in almost any application. And of course since he sells every type of chain he is in a position to make completely unprejudiced recommendations. A good man to cultivate, the Union Chain man.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

Circle 485 on Page 19

Now! THE ALL-NEW

DPS MODEL U (Universal) POWER SCREWDRIVER

WITH BRAND NEW FEATURES AND ADVANTAGES NEVER BEFORE AVAILABLE



NEW TYPE POSITIVE CONTROL CLUTCH

- Not affected by changes in temperature or excessive oil or grease
- Sharply increased accuracy as to variation in torque tolerance
- Simplified design for easy servicing
- Requires no daily lubrication
- No friction devices of any kind used
- Long service life on all parts subject to wear

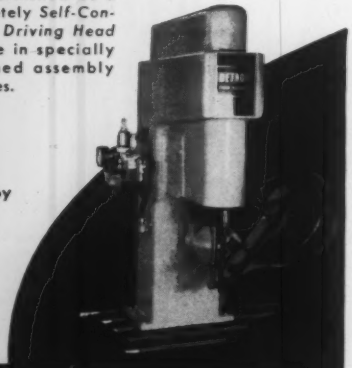
NEW TYPE HOPPER DRIVING MECHANISM

- No gears to wear out
- No lubrication required
- No costly replacement parts
- Simple design for easy servicing
- Built-in slip control as a safety feature

NEW TYPE FEED TRACK AND ESCAPEMENT MECHANISM

- Flexibility for easy and fast adjustment
- Escapement does not require daily lubrication
- Escapement design permits releasing screws by body or head as required
- Positive solenoid action
- Simple design for easy servicing
- Adjustable for full capacity of machine

Also furnished as a completely *Self-Contained Driving Head* for use in specially designed assembly machines.



Write for NEW BROCHURE!

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT STREET DETROIT 16, MICHIGAN

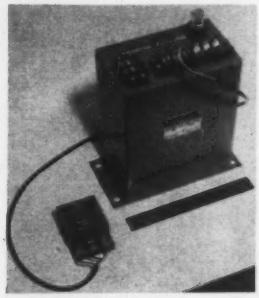
to 3/8 in. diam. Units are furnished in grip-length increments of 1/16 in. **Standard Pressed Steel Co.**, Jenkintown, Pa. C

Circle 634 on Page 19

Proximity Switch

has 24 x dc output at 0.335 amp

New proximity limit switch is designed to be independent of switching operations performed. Electrical output of 24 v dc at 0.335 amp drives Cypak and other static control elements, and 24-v dc relays and solenoids. Switch consists of an encapsulated sensing element, containing an open C-core and two windings as elements of a variable reluctance bridge circuit, and a steel-



encased, sealed control element, containing balance, circuit, amplifier, phase detector, precision flip-flop circuit, transistor output amplifier, and power supply. Unit has speed of up to 20 operations per sec and resists shock, vibration, corrosion, and humidity. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 22, Pa. F

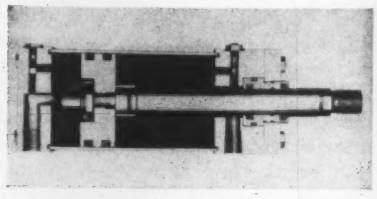
Circle 635 on Page 19

Cylinders

for air and low-pressure hydraulic applications

Series R2 cylinders for air and low-pressure hydraulic applications are available in eleven bore sizes. They are rated at 200 psi air and 500 to 2500 psi hydraulic, depending on bore size and application. All bore sizes are available in twelve mounting styles, and all models but clevis mount can be provided as double-rod end cylinders. Three piston-rod end styles—large external thread, small external thread, and internal thread—are also available. Piston

Circle 486 on Page 19



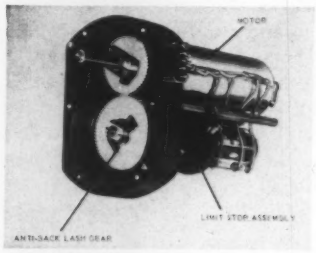
rods are hardened and hard-chrome-plated, and have 100,000 psi minimum yield strength. Pressure-sensitive barrel seals eliminate external leakage. Metal-to-metal floating cushion at gland end permits maximum cushion effect without binding. **Hydro-Line Mfg. Co.**, 5600 Pike Rd., Rockford, Ill. K

Circle 636 on Page 19

Rotary Actuator

has integral limit switches

New rotary actuator consists of a small, high-torque motor coupled to limit switch and potentiometer drive with an antibacklash gear. Gear transmits potentiometer torque only. Limit switches are adjustable from zero to maximum number of turns. Actuator is furnished in several styles, flange or foot mounted, and with one or more potentiometers. Standard models are rated ¼ to 150 rpm, 150 lb-in. maximum torque, and 3 to 30 turns. Motor has high acceleration, and can be



furnished with torque-limiting clutch. **United Hydraulics Inc.**, 110 Terrell Court, Dayton 7, Ohio. G

Circle 637 on Page 19

Molding Compound

combines high strength with conformability

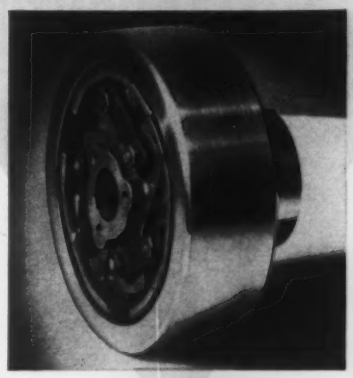
Scotchply high-strength molding compound, Type 1100, offers an average flexural strength of 100,000 psi, average tensile strength of 40,000 psi, and average compressive strength of 38,000 psi at normal temperatures. It is for use in the

CLUTCHES FOR POWER CONTROL DESIGNS

THE NEW HILLIARD-TWIFLEX
Centrifugal Coupling

1
AUTOMATIC
smooth starting with protection against overload shock.

2
FLEXIBLE
in all directions without any loose joints.



3
ADJUSTABLE
to exactly suit the operating conditions.

4
SIMPLE CONSTRUCTION
and easy assembly even in blind installations.

HILLIARD-TWIFLEX Centrifugal Couplings provide automatic shockless power transmission and trouble-free operation even under relatively great misalignment without any lubrication whatsoever.

They are being used very successfully in the drive of compressors—agricultural sprayers—mixers—conveyors—generators—fans and blowers—pumps—hammer mills—crushers—winches and hoists—refrigeration equipment—textile machinery—and wherever smooth, efficient operation is needed.

Tests in a variety of installations for over five years prove the Twiflex is the practical solution to many drive problems.

WRITE TODAY FOR BULLETIN CE-3 WITH COMPLETE INFORMATION.

★ *CONSIDER AUTOMATION-INVESTIGATE THESE PRODUCTS*

• OTHER HILLIARD CLUTCHES •

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—or intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

THE HILLIARD *Corporation*
MANUFACTURING CLUTCHES FOR OVER 50 YEARS

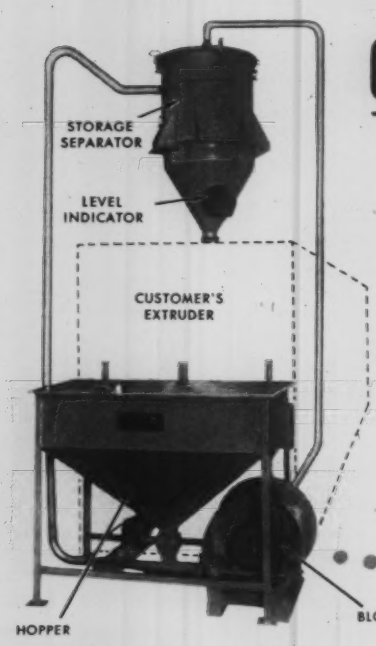
103 W. FOURTH ST., ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

Circle 487 on Page 19

Design Problem Here Was

CONTINUOUS FEEDING OF PLASTIC PELLETS



SPENCER Blowers Provided the Solution

This designer's problem was to find a means of *automatically* feeding plastic pellets into extruders—*continuously*. A *closed* system was necessary to prevent contamination of material with atmospheric dust and to prevent escape of plastic "fines".

A Spencer blower, incorporated with the customer's equipment as shown, solved the problem. Pellets in hopper are gravity fed through a rotary valve into the air stream, then conveyed up to the storage separator as required.

When level indicator registers sufficient drop in level, another quantity of pellets is fed from the bin into the extruder.

Spencer will be glad to assist in adapting standard blowers or vacuum producers—or designing special units—to meet *your* particular needs.

Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM"
Bulletin 144 illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"
Supplies application data on Spencer Blowers. Request Bulletin 107-C.

STANDARD CAPACITIES
of Spencer Blowers
⅓ HP to 1,000 HP
Up to 20,000 CFM
4 oz. to 10 lbs. pressure

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Circle 488 on Page 19

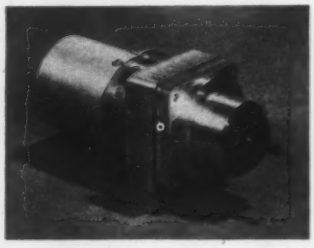
aircraft manufacturing field where high strength and low weight are of prime importance. Material is suitable for making complex parts because of its ability to flow and the tendency of its fibers to distribute evenly under pressure. Compound is supplied in dry form, and is adaptable to either compression or transfer-molding processes. **Minnesota Mining & Mfg. Co.**, Dept. F8-160, 900 Bush St., St. Paul, Minn. J

Circle 638 on Page 19

Constant-Speed Drive

holds output speed to ±0.1 per cent

New constant-speed power drive is designed for computer and control-system applications. At a constant speed of 1000 rpm, 16 oz-in. of torque can be obtained. Tolerance on speed is ±0.1 per cent with input voltage variation of ±20 per cent and input speed of 1100 rpm ±15 per cent. Typical unit, type 041-9902, measures 4¼ x 2 x 2 in. and weighs about 1 lb. It utilizes a timing motor requiring 28 v dc at 3 w. **M. Ten Bosch Inc.**, Pleasantville, N. Y. D

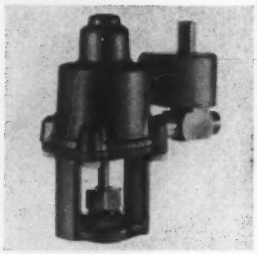


Circle 639 on Page 19

Industrial Cylinder

is solenoid controlled

Heavy-duty, industrial-type cylinder with built-in solenoid pilot valve controls heavy-duty levers, latches, and dampers, wherever mechanical motion is involved. Cylinder is single acting, and is controlled by a three-way solenoid valve arranged to apply or vent pressure alternately. Changes in stroke or load in pounds do not affect current inrush. Two sizes are available, a 3½-in. size with maximum load of 50 psi at 360 lb, and a 2¼-in. size with maximum load of 150 psi at 375 lb.



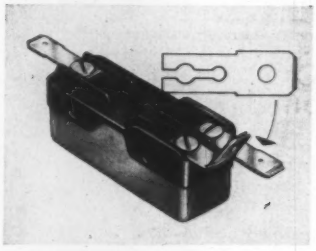
Cylinder operates on air, water, or oil at pressures from 10 to 150 psi, and at any standard ac or dc voltage. **Automatic Switch Co.**, Florham Park, N. J. D

Circle 640 on Page 19

Quick-Connect Terminals

for sensitive snap-action switches

New male snap-on terminals provide firm, vibration-resistant installation to high-sensitivity, snap-acting miniature switches. Terminals fit between molded barriers on switch base, and securing screw spreads slotted end to give solid, no-turn installation that resists shock and vibration. Terminals are ¼ in. wide, made of 0.032 in. half-hard brass, and are indented for tight connection. They are furnished for straight-on or up to 90-



deg angle connection, and fit standard female quick-connect terminals. **Unimax Switch Div., W. L. Maxson Corp.**, Wallingford, Conn. B

Circle 641 on Page 19

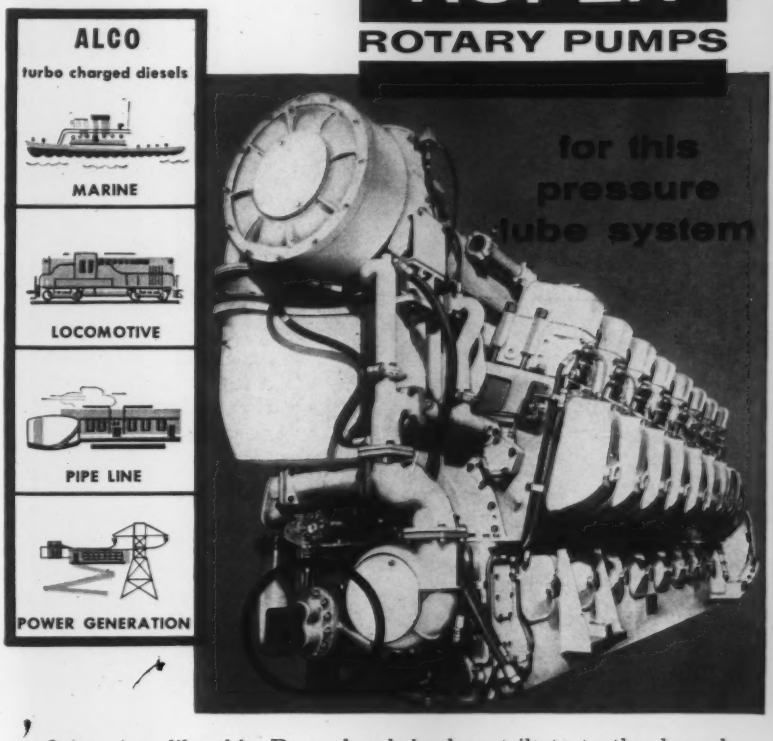
Steel Hub

for assembly of industrial equipment

New all-steel weld-on hub, designed for assembly of sprockets, pulleys, sheaves, gears, couplings, and other industrial equipment, is adaptable to various shaft assemblies without increasing overall length of product itself. Hub is provided with alloy-steel compression set screws that

ALCO Chose

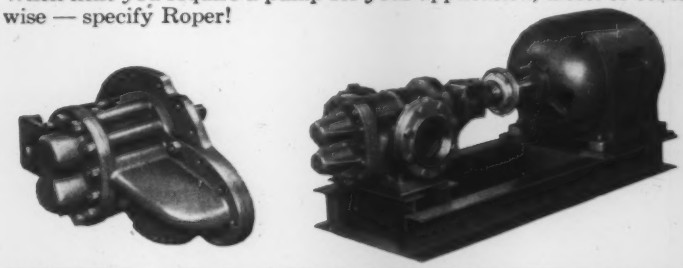
ROPER ROTARY PUMPS



On engines like this, Roper has helped contribute to the dependability of Alco diesels and the 15-million Alco diesel horsepower that have been built for railroad, power-generating, marine, pipe-line, and oil drilling service.

In the circle you see the special Roper — a rugged, compact, heavy-duty pump that is the mainstay of this 16-cylinder diesel's pressure lube system.

When next you require a pump for your application, diesel or otherwise — specify Roper!



CUSTOM AND STANDARD PUMPS FOR DIESELS

or wherever pressure lubrication or transfer are needed

In addition to custom designing when required, Roper offers a wide range of standard and special units which may be fitted into your plans. A look at your needs, and our engineering staff will come up with the pump that can handle the job smoothly, efficiently, and dependably.

ROPER ROTARY PUMPS

Send for Catalog

ROPER HYDRAULICS, INC.

248 BLACKHAWK PARK AVE., ROCKFORD, ILL.

Circle 489 on Page 19

The tough, good looking finish—

PARKERIZING

...low cost, too!

If these are your finish requirements—excellent corrosion resistance, adaptability, economy, and good appearance for iron and steel—then Parkerizing is the finish for you.

This treatment is used on practically all types of parts and products: screws, bolts, stampings, forgings, castings and machined parts. There are no restrictions on size or shape. Treatment takes only a few minutes, is completely dependable. Installation and operation is simple, requires a minimum of floor space, equipment and manpower.

Treatment with Parkerizing builds a protective coat of non-metallic phosphate over all surfaces of the metal, barring corrosive forces. This resistant coating may be waxed, stained, oiled or painted.

For high rust resistance, uniform quality, and protected fine appearance, use this pioneer surface treatment that has been proved and improved for more than 44 years—Parkerizing! Call in the Parker man in your area.

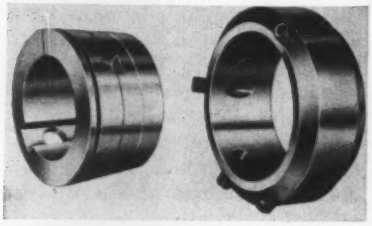
PARKER

RUST PROOF COMPANY

2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base	PARCO COMPOUND rust resistant	PARCO LUBRITE wear resistant for friction surfaces
BONDERITE and BONDERLUBE aids in cold forming of metals		TROPICAL heavy duty maintenance paints since 1883

Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.



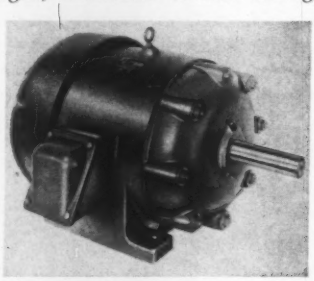
mount flush with hub surface. Split tapered bushings have precision-ground diameters, and split construction provides for full grip on undersized shafts. **Cullman Wheel Co.**, 1344 Altgeld St., Chicago 14, Ill. J

Circle 642 on Page 19

Explosionproof Motor

is housed in heat-treated aluminum alloy

New explosionproof motor is housed in heat-treated aluminum alloy enclosure, and has no external cooling fins. Absence of fins makes motor suitable for use in dusty or dirty explosive atmospheres. Motor is approved for Class 1, Group D (gasoline vapor) and Class 2, Groups F and G (explosive dusts) service, in new NEMA rerated frames 254U-256U, 284U-286U, and 324U-326U. Aluminum housing provides lighter weight, increased tensile strength,



and greater corrosion resistance than conventional materials. **Electra Motors Inc.**, 1110 N. Lemon St., Anaheim, Calif. L

Circle 643 on Page 19

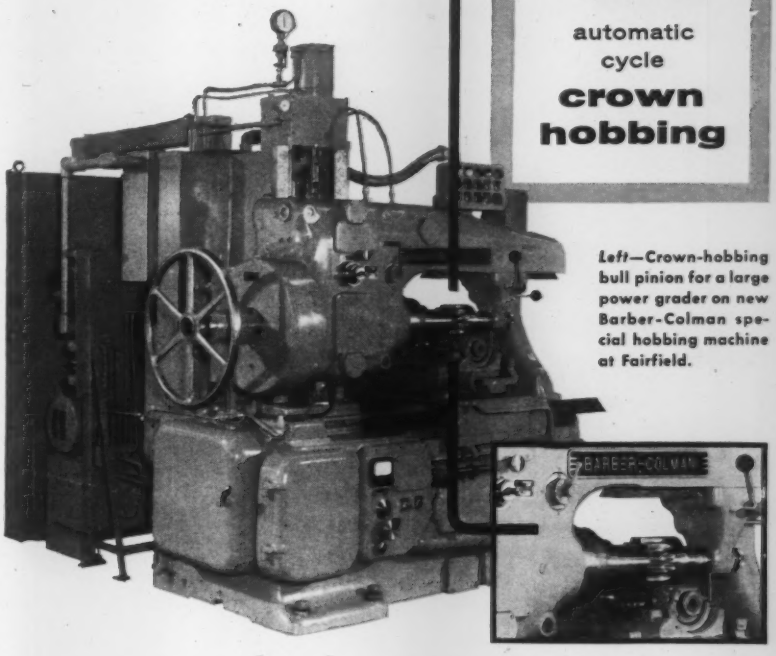
Molded Nylon Screws

in new sizes and head types

Close-tolerance molded nylon screws are now furnished in new thread sizes, head types, and lengths. Available are molded nylon machine screws, and headless set screws in sizes No. 4-40, 6-32, 8-32,

another new, ultra-modern
FAIRFIELD GEAR MAKING
facility . . . .

automatic cycle **crown hobbing**



Left—Crown-hobbing bull pinion for a large power grader on new Barber-Colman special hobbing machine at Fairfield.

Saves Time! Cuts Costs! Produces Better Gears *for you*

You get every benefit of latest cost-cutting methods and equipment when your gears are produced by Fairfield. "Automatic Cycle Crown Hobbing" is one interesting example of a new method for generating *accurately* crowned teeth on spur gears and pinions. In addition to significant time savings produced by a remarkably versatile machine, subsequent finishing costs can be reduced, or may be completely eliminated. Special tooth strength characteristics may also be obtained economically.

Check with Fairfield on all of your gear requirements. You get the advantage of high production rates and big volume output in an ultra-modern plant designed exclusively for producing fine gears EFFICIENTLY, ECONOMICALLY. *Call or write.*

FAIRFIELD
MANUFACTURING CO.
2307 S. Concord Road Lafayette, Indiana
TELEPHONE: 2-7353

Ask for interesting, illustrated bulletin.

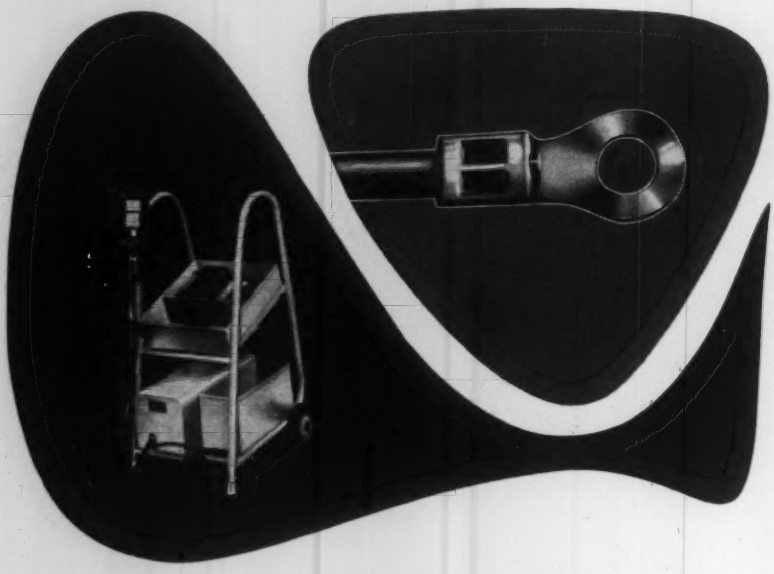
Gears and Differentials Made to Order for:

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

Circle 491 on Page 19

AMP® SOLISTRAND® Terminals

and DYNA-CRIMP® tools—



the right combination . . .

for electrical power generation and distribution

Take any assortment of conductors—solid, stranded or irregularly shaped. Add one A-MP Solistrand terminal. Bring them together in the proper A-MP Dyna-Crimp tool.

The result is always the same—an electrically-perfect, crimp-sure attachment at lower installed cost. Top performance even in adverse conditions.

And Solistrand needs no servicing. This is especially valuable where you have power machinery that must be left unmanned for long periods. Check these important Solistrand features:

- Exclusive double-indented crimp weds Solistrand barrel to conductors in a never-fail attachment.
- Crimping action of Dyna-Crimp tools forces combinations of conductors into one homogeneous mass. It does this at exactly the right pressure—no more, no less—for maximum conductivity and maximum strength with no weakening of conductors.
- Solistrand terminals are scientifically engineered in sizes to fit wires from No. 22 to 600 mcm.

And to serve you better, AMP maintains an international staff of field engineers capable of solving all your terminal problems.

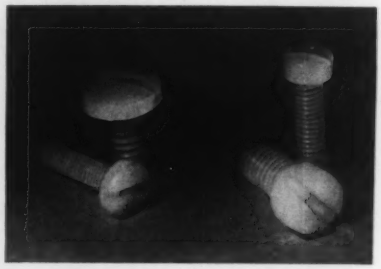
Write for our Solistrand terminal and connector catalog.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan

10-32, and ¼-20. Lengths range from ¼ to 1 in., with standard increments of ⅛ in., and special intermediate lengths are also available. Machine screws have, in addition to standard binding head, round, fillister, and flat heads, in Phillips or slotted types. All types



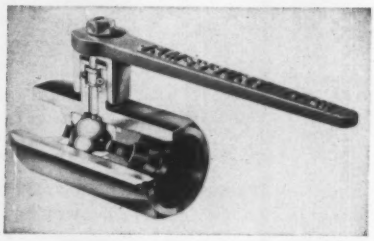
except flat head are available with integral washer molded beneath head of screw. Headless set screw is furnished with a variety of points, including plain, cone, oval, flat, half-dog, and full-dog. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y. D

Circle 644 on Page 19

Ball Valves

for high-pressure uses

Style H Double-Seal ball valves are available in ¼ to 1½-in. sizes for straight tubing thread style, and in ½ to 2-in. sizes for standard pipe thread style. Valves are recommended for high-pressure use on hydraulic equipment and in systems



using compressed gases. They are available with carbon steel, 303 and 316 stainless-steel bodies, with nylon or Teflon seats and seals. **Jamesbury Corp.**, Dept. H, 45 New St., Worcester, Mass. B

Circle 645 on Page 19

Phosphor Bronze Strip

is cadmium-silver clad

Cadmium - silver clad phosphor bronze strip has excellent electrical

Now AVAILABLE "MECHANICS OF VEHICLES"

By

JAROSLAV TABOREK

A comprehensive study of the principles of vehicle motion from the designer's viewpoint. A complete reprint of the 14-part series appearing in MACHINE DESIGN.

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Penton Building

Cleveland 13, Ohio

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(Remittance or Company Purchase Order must be enclosed with order.)

contact properties and electrical conductivity. Phosphor bronze base provides good spring properties to make the material suitable for the manufacture of electrical contact springs. Silver overlay is made from fine, coin, or sterling silver, rolled to commercial or mirror finish. Material is supplied in all types of cladding, including overlay, inlay, edgelay, throughlay, and abovelay. Thickness ratios extend from 99 per cent cadmium-silver down to less than 1 per cent, and width tolerances are ±0.0015 in. **American Silver Co. Inc.**, 36-07 Prince St., Flushing 54, N. Y. D

Circle 646 on Page 19

Air-Line Filter

operates on pressures from 10 to 250 psi

Redesigned float-operated air-line moisture separator, designated Aqua-Jet, separates moisture and other contaminants from compressed-air lines. Filter operates on pressures from 10 to 250 psi, with continuous or intermittent flow, with small pressure drop and no flutter. Built-in impregnated felt cartridge protects operating parts against rust and grit. Unit is available with metal or transparent bowl for pipe lines from ¼ to 8 in. **Wilkerson Corp.**, 1646 W. Girard Ave., Englewood, Colo. K

Circle 647 on Page 19

Filtering Elements

of bronze or stainless steel

New filtering elements are either sintered bronze or 316 stainless steel to meet any filtering requirements. Filtration selections are available in bronze elements within ranges of

GEAR-GRIP

The most revolutionary Flexible Coupling Design Development in a century!

●

Now available for sub-fractional, fractional and integral H.P.

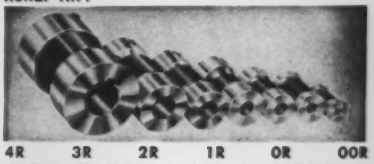
●

Ability of rubber Flex-Element to float between captive end fittings distributing load similar to universal joint action.

- **Load Ranges—1/12 H.P. through 30 H.P.**
- **Shaft Sizes—1/8 through 1-7/8.**
- **Specified exact length to design requirements per series.**
- **Prevention of end thrust among many other design advancements.**

Dyna-Line . . .

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



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- **True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.**
- **Lengths varied to design specifications in each series.**
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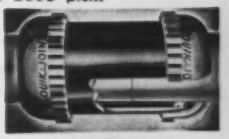
- **Shaft sizes—3/16" to ¾".**

Quick-Joint

Steel Compression Pipe Fittings

- **UL approved for hazardous fluids.**
- **Guaranteed for 2000 p.s.i.**
- **Allows 7° angular deflection.**
- **No threading of pipe required.**
- **Special S111-cone Gasket for Steam applications.**



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Guardian PRODUCTS CORP.

COUPLING DIVISION

Dept. MD-88

Michigan City, Indiana

Circle 493 on Page 19

time to re-examine

BEARING APPLICATIONS

Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.

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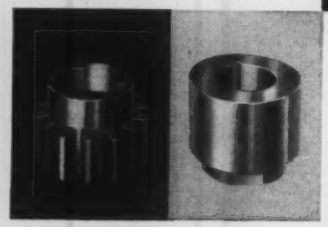

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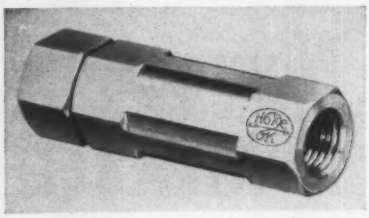
Circle 494 on Page 19



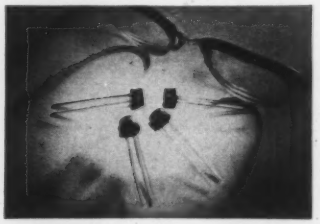
5-12, 12-25, 25-50, 50-125, or 150-200 mu, and in stainless-steel elements within ranges of 5-7, 7-10, and 10-13 mu. Body of filter is available with 1/8, 1/4, 3/8, and 1/2-in. female pipe connections and is designed to permit replacement of filtering element. Maximum operating pressure is 5000 psi, and temperature limits range from − 60 to 450 F. **Hoke Inc.**, 136 S. Dean St., Englewood, N. J. D

Circle 648 on Page 19

Germanium Transistors

for use in switching applications

Four new pnp medium-speed transistors are designed for use in digital computers and other switching applications. JETEC type designations are 2N394, 2N395, 2N396, and 2N397. Transistors can be used in either saturating or nonsaturating circuits. At collector current of 10 ma, units have minimum dc current-gain ratings of 20, 25, 30, and 30 respectively. Maximum



emitter-to-base voltage rating is 10 v at 25 C. Section RWS, **Semiconductor Products Dept., General Electric Co.**, Syracuse, N. Y. C

Circle 649 on Page 19

Aluminum-Iron Alloy

for magnetic applications

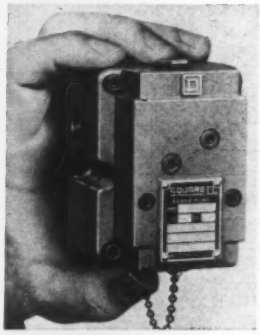
Carpenter 12 Alfenol is a high-permeability, 12 per cent aluminum-iron alloy for use in magnetic-tape pickup heads, servo and synchro laminations, and thin-gage toroidal-tape cores. Advantages

cited over comparable nickel-iron and silicon iron alloys include: greater resistance to wear and abrasion; less eddy-current loss in laminations at high frequencies; greater magnetic stability and performance at temperatures to 500 C; high electrical resistivity. Magnetic permeability increases when material is exposed to radiation. Alloy is available as unannealed cold-rolled strip varying from 0.002 to 0.025 in. thick, with coil widths to 3 in. weighing from 1 to 30 lb per in. width. Carpenter Steel Co., Reading, Pa. E

Circle 650 on Page 19

Rotary Air Valve

for mounting in any position



Four-way air valve for use with spot welders, pneumatic tools, and other industrial applications, incorporates a rotary magnet which permits mounting in any position. Small size of valve permits mounting at the cylinder, eliminating need for long air lines. Valve meets JIC specifications, including chain-attached cover and oiltight enclosure. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 651 on Page 19

Rotary Converters

dc to ac units
have up to 3000-w output

Line of rotary converters has been extended to include units with 3000-w output. Larger sizes meet needs for small amounts of direct current and for special applications, including many marine uses, which require more dc than is supplied by most standard converters. Line extends from 100 to 3000-w ac output, with more than 50 dc input

New Cap Fastener for Unthreaded Rod

PUSH OR TAP --IT'S ASSEMBLED

on plain round rods, axles, studs, rivets, pins, shafts

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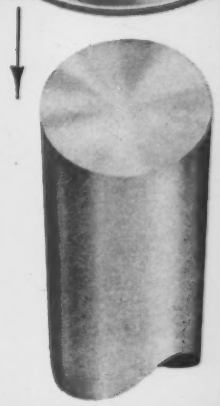
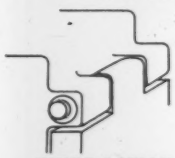
Saves cost of threading --notching--drilling for cotter pins



TYPE W PUSHNUT FASTENERS

Type W PUSHNUT Fasteners are made in one piece of heavy gauge tempered spring steel, with a special locking action that grips unthreaded rod and exerts powerful resistance to removal from 1/10 to 1/2 ton. On knocked down assemblies they are easily applied by tapping with a hammer. In factory assembly, readily applied by air hammer, press, or jigs for multiple assembly.

TYPICAL APPLICATIONS



HINGE ACTION
Rivet: Headed on one end, with PUSHNUT on other. Pin: PUSHNUT on each end.

PIVOT ACTION
Retainer on bell cranks or levers on integral studs or shafts.

CAPPED ASSEMBLY
Smooth, attractive assembly of parts not required or desired to be held under heavy tension or pressure.

HUB CAP WHEEL RETAINER
Attractive, reliable fastening of wheels on axles of all kinds of vehicles.

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- Rugged holding power
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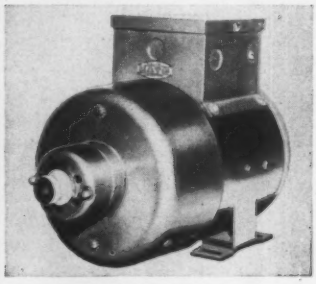


and ac output combinations available. **Kato Engineering Co.**, Mankato, Minn. J

Circle 652 on Page 19

Vulcanized Fiber

flame-resistant material is for mechanical applications

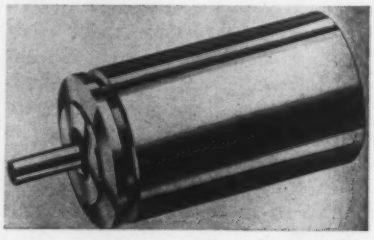
New vulcanized fiber, designed for mechanical applications where flame resistance and self-extinguishing qualities are important, incorporates an additive that completely penetrates material and makes it flame resistant. Fiber does not have good electrical properties associated with standard vulcanized fiber, and is not recommended for use where arc resistance is important. **National Vulcanized Fibre Co.**, 1058 Beech St., Wilmington 99, Del. C

Circle 653 on Page 19

Servomotor-Generator

is size-8 unit

Model 8 MG 420/410 servomotor-rate generator is only 1.350 in. long and weighs 1.9 oz. Motor and generator reference windings operate from a 26-v 400-cycle source; motor control windings take up to 52 v. Time constant is 5.7 millisec, generator input power, 1 w, motor input power, 2.3 w per phase, no-load speed, 6000 rpm. Unit operates continuously at stall with both windings fully excited through ambients from − 55 to 130 C. Motor-generator withstands 100 g shock and 30 g vibration to 2000 cycles,



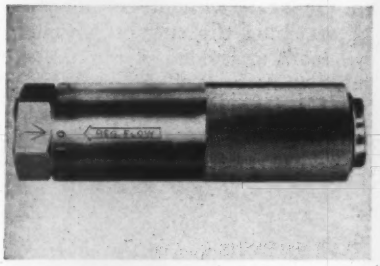
exceeding specifications of MIL-E-5272A. **Helipot Corp., Div., Beckman Instruments Inc.,** Newport Beach, Calif. L

Circle 654 on Page 19

Flow Regulator

has built-in check valve

New in-line, pressure-compensated, adjustable-flow regulator is available in ¼, ⅜, and ½-in. pipe sizes for flow rates to 5, 10, and 18 gpm, respectively. Maximum operating pressure is 3000 psi. Changes in flow rate are accomplished by rotation of valve sleeve. Calibrations on sleeve facilitate repeat flow set-



tings. Built-in check valve provides for free flow in noncompensated direction. **Fluid Power Accessories Inc.,** P. O. Box 64, Glenview, Ill. J

Circle 655 on Page 19

Ethylenic Coated Fabric

has long flex life

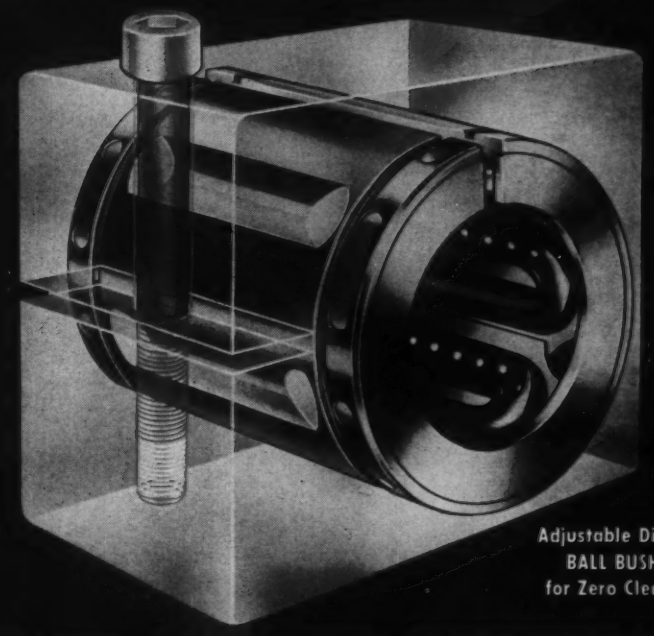
Armalon opaque coated fabric remains pliable in both hot and cold temperatures, possesses an unusually long flex life, and has excellent resistance to edge wear. Designed primarily as a heavy-duty camera-bellows material, the fabric has other applications in aircraft and industry, including darkroom curtaining, pull shades in military aircraft, protective covers for flight instruments, drawing-board covers, and dust covers for industrial equipment, particularly where a high degree of mar resistance is required. Material is unaffected by contact with lacquered surfaces. It is available in black and gray in 0.007 and 0.010-in. gages and in 36 and 42-in. widths. **E. I. DuPont de Nemours & Co.,** Room 7031-D, Wilmington 98, Del. C

Circle 656 on Page 19

Circle 497 on Page 19→

NOW! Adjustable Diameter and Open THOMSON

BALL BUSHINGS



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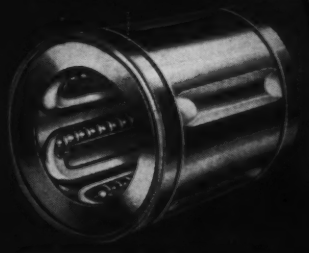
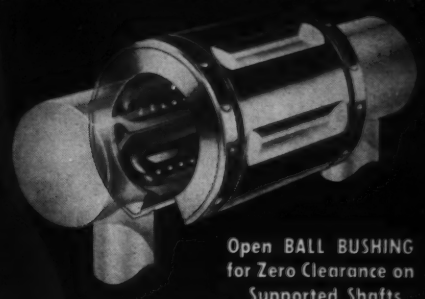
The BALL Bearing for *all* your LINEAR MOTIONS



Precision Series "A" and Low Cost Series "B" BALL BUSHING



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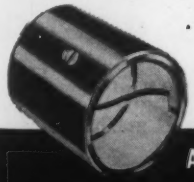
The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



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Circle 498 on Page 19

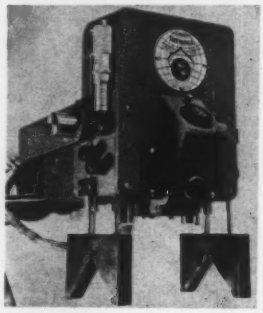
ENGINEERING DEPARTMENT

EQUIPMENT

Torque Transducer

converts color into electrical signals

PhotoStress torquemeter is a servo-operated, null-balance system consisting of two polarizing channels pointed at the shaft. Cylinder of PhotoStress plastic, which converts strain into color, is bonded to the shaft without cutting shaft or attaching slip rings. One channel looks at bonded plastic and the other at unbonded dummy plastic. System compares signals from the bonded and unbonded plastics, canceling out effects of temperature and external light, photocell sensitivity, and power-supply stability. It converts color into electrical signals. Thus color patterns can be recorded on oscillographs or other recorders, or indicated on meters with no contact between transducer and part being measured. Readout is directly in digits, and in millivolts. Accuracy is better than ¼ per cent full scale. Same system can be used with pressure cells, load cells, extensometers, flow meters, and stress analysis. **Tatnall Measuring Systems Co.**, P. O. Box 245, Phoenixville, Pa. E

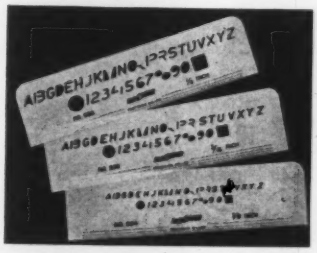


Circle 657 on Page 19

Slant-Letter Template

facilitates equally spaced lettering

No. 930 slant-letter set, designed to facilitate equal-spaced lettering, con-



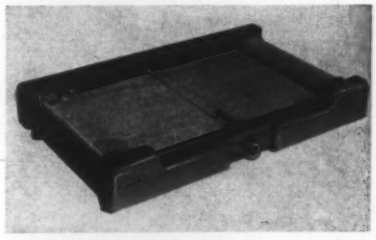
sists of three lettering guides with letters and numerals 15 deg from vertical. Letters are 1/8, 3/16, and 1/4 in. high. Each template is 0.030-in. mathematical-quality plastic, and measures 6 7/8 x 1 7/8 in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 658 on Page 19

Chart Viewer

accepts charts up to 16 in. wide and 200 ft long

Model 276 oscillographic recording chart viewer provides variable chart drive speeds from 15 in. to 100 ft per min, and accepts charts to 16 in. wide and 200 ft long. Viewer has a direction-reversing switch combined with speed control to allow rewinding at any time, and has automatic braking to prevent supply roll overrun when speed is reduced. Chart table is finished in black to provide best viewing of translucent charts, and is equipped with a trans-



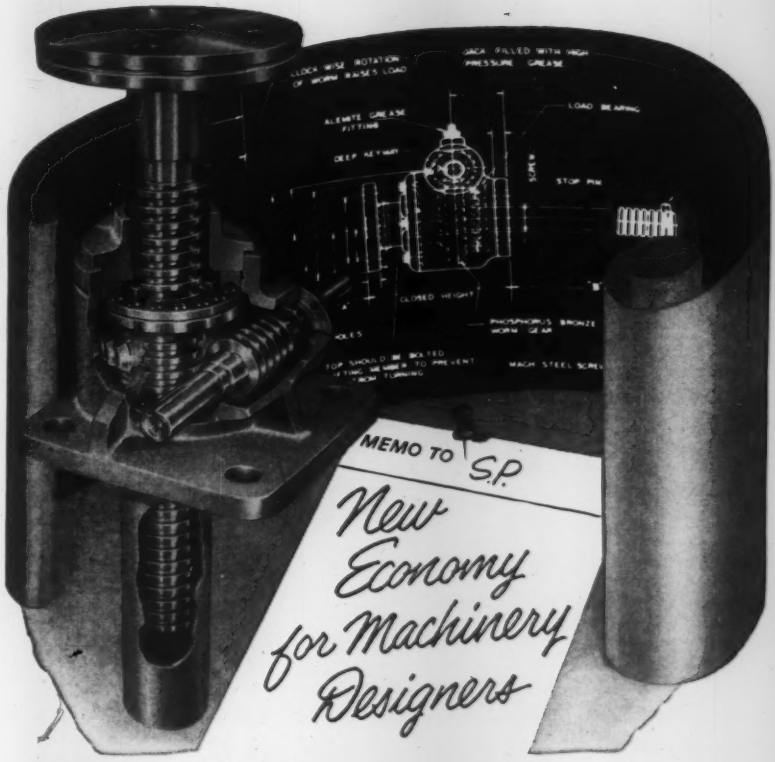
parent plastic cursor to facilitate examination and correlation of multichannel recordings. Over-all dimensions are 36 x 22 1/2 x 7 1/4 in. high, and total weight is approximately 25 lb. **Industrial Div., Sanborn Co.**, 175 Wyman St., Waltham 54, Mass. B

Circle 659 on Page 19

Accelerometers

for high-temperature use

AXT self-generating accelerometers operate continuously at temperatures from −100 to 500 F with ac-



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Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

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Circle 499 on Page 19

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—nor cut or stick to the shaft because of temporary lubrication failure.

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Circle 500 on Page 19

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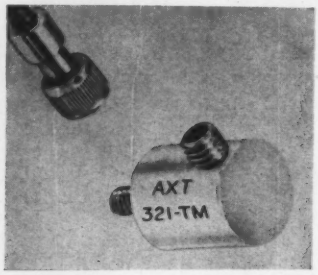
curacy of ± 5 per cent of actual reading. Bender-type piezoelectric construction provides low acoustic sensitivity, extremely small size, light weight, and high frequency response. Exhibiting less than ±5 per cent change in sensitivity over entire temperature range, accelerometers require no cooling. They are available with resonant frequencies to 30 kc and sensitivities to 10 mv per g. They measure shock and vibration in aircraft and missiles, and cover a range of 1/100 to 1000 g over frequencies of 3 to 10,000 cps. Instruments for both unidirectional and tridirectional measurements are available. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J. D



Circle 660 on Page 19

Power Supply

transistorized unit provides 28-v dc power

New transistorized dc power supply is designed for use in computers and laboratory test equipment. It provides 28-v dc power, 0-5 amp, and operates from any 115-v, single-phase, 60-cycle power source. Voltage regulation from no load to full load is 0.1 per cent with ±10 per cent change in input; peak-to-peak ripple is 0.001 per cent. Power supply is available in cabinet or for relay rack mounting. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 661 on Page 19

THE ENGINEER'S

Library

Recent Books

Fluorocarbons. *By Merritt A. Rudner; 238 pages, 5¼ by 7¼ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $5.75 per copy.*

This book covers the properties, processing and fabrication techniques, and final applications of fluorocarbons. It also compares their capabilities and limitations with other plastics.

Transistor Physics and Circuits. *By Robert L. Riddle and Marlin P. Ristenbatt; 428 pages, 6 by 9 in., clothbound; published by Prentice-Hall Inc., 70 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$10.00 per copy postpaid.*

This book describes the recent transistor developments, and gives attention to the physical operation of transistors as well as their circuitry.

Cellulosics. *By Walter D. Paist; 270 pages, 5¼ by 7¼ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $5.75 per copy.*

This book presents a survey of the applications of cellulosics, based on their properties. Chapters include such topics as chemistry, properties, and fabrication methods, along with examples of their applications.

Modelmaking for Industrial Design. *By Ralph R. Knoblaugh; 276 pages, 6½ by 10 in., clothbound; published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., available from* MACHINE DESIGN, *$9.75 per copy postpaid.*

This book presents instructions for building models of plaster, plastics, metal, and wood to express design ideas in three dimensions. Included are the procedures for determining the materials and proc-

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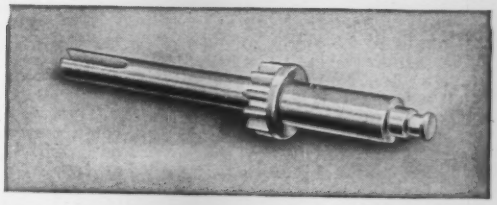

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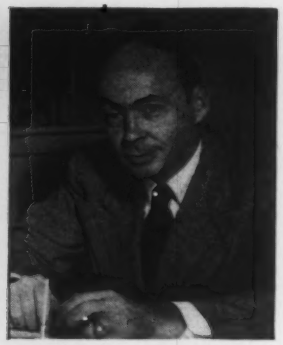
MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.



CONTACT ANGLE

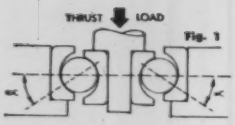


Fig. 1

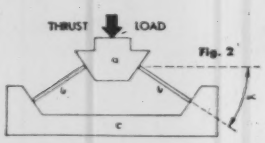


Fig. 2

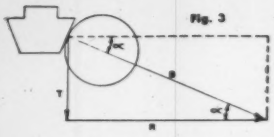


Fig. 3

Contact angle is the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where the ball makes contact with the raceways when the bearing is subjected to a pure thrust load. In *Fig. 1*, the contact angle is represented by angle α. The significance of the contact angle is revealed by an examination of the forces present in a thrust loaded bearing.

In *Fig. 2*, a simplified version of *Fig. 1*, the shaft and inner ring combination are represented by the plug *a*, the "working diameters" of the balls and represented by the rodlike members at *b*, and the outer ring is represented by the tapered cup *c*.

The contact angle is α. This diagram represents a three-dimensional structure with as many equally spaced rods, *b*, as there are balls in the bearing.

The primary concern in design is the amount of compressive force to which rod *b* is subject, which is the force with which a given ball is pressed against the raceways. This force can be calculated by constructing a parallelogram of forces as shown in *Fig. 3*.

The sides T and R, are vector quantities, and diagonal B is the vector sum of T and R. Furthermore, the vector sum of the thrust components on all the balls equals the total thrust load on the bearing. The vector sum of the radial components on all the balls is zero. Vector B, the force actually felt by the raceways and balls, compared to vector T, the thrust component, varies significantly with changes in the size of the contact angle and is directly proportional to the thrust load component and inversely proportional to the sine of the contact angle.

Example I:

A bearing is carrying a pure thrust load of 21 pounds. Assuming seven balls in the bearing, each ball will have an axial load component of three pounds, since a thrust load is shared equally by all the balls. While the axial component on each ball is only three pounds, the actual compressive force, or squeeze, felt by the ball and raceways is considerably greater than this value.

With a contact angle of five degrees:

$$B = \frac{T}{\sin \alpha} = \frac{3 \text{ lbs.}}{\sin 5^\circ} = 34.5 \text{ lbs.}$$

Thus we see that with a five-degree contact angle the actual load felt by each individual ball is actually considerably greater than the total 21 pound thrust load on the bearing.

Example II:

Using the thrust conditions in Example 1, the contact angle is increased to 20 degrees, by selecting a bearing with a larger value of radial play.

$$B = \frac{3 \text{ pounds}}{\sin 20^\circ} = 8.78 \text{ pounds}$$

A 15 degree increase in contact angle produced a 74.5% reduction in ball-to-raceway contact stress. This relationship should be noted by anyone who writes bearing specifications. The operational qualities of the bearing, such as low running and starting torque and bearing life, are a function of the ball-to-raceway contact stress. Thus the contact angle is highly significant.

It is not necessary for a bearing user to calculate or specify the contact angle desired. It is only necessary to remember that low values of contact angle are associated with low radial play, and high values of contact angle are associated with high radial play. In addition to the above considerations, gyratory forces become extremely important factors in determining optimum contact angle in high speed applications.

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esses to use, for laying out the parts from which the model is made, and for assembling and painting the model.

Engineering Economy. *By Clarence E. Bullinger, professor of Industrial Engineering, Iowa State College; 379 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 W. 42nd St., New York 36, N. Y., available from* MACHINE DESIGN, *$7.00 per copy postpaid.*

This book describes the three economic studies which engineers in industry make when considering the functional solution of engineering problems. The procedures outlined for economic, intangible, and financial analyses show how to evaluate whether a project is worthwhile.

New Standards

ASTM Specifications for Steel Piping Materials, A-1. *460 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $5.00 per copy.*

This compilation of 62 ASTM standards on steel piping materials contains specifications for carbon-steel and alloy-steel pipe and tubing.

American Standards, ASA Y14.7-1958. Gears, Splines and Serrations. *Published by and available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y., $1.50 per copy.*

This section of the American Drafting Standards Manual defines the basic minimum drawing information for the manufacture and inspection of gears. It also indicates optional information frequently required for specific definition of process control or product quality.

Association Publications

Radiation Effects on Materials, Volume II, STP 220. *140 pages; 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $3.75 per copy.*

Radiation effects on materials, facilities and techniques for radiation

testing, and design considerations for radiation are some of the topics discussed in this symposium.

Elevated-Temperature Properties of Weld-Deposited Metal and Weldments, STP 226. *228 pages, 8½ by 11 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $5.50 per copy.*

This publication presents elevated-temperature data obtained from tests on 30 steel and steel alloy welds. Data on tensile strength, yield strength, elongation, area reduction, rupture life, and creep for each material tested are included.

ASTM Proceedings, Volume 57. *1430 pages, 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $12.00 per copy.*

Contained in this book of proceedings are 52 technical papers on research and testing of materials. Results of investigations on fatigue behavior and elevated-temperature characteristics of steel and other metals are among the topics discussed.

Nondestructive Tests in the Field of Nuclear Energy, STP 223. *420 pages, 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $10.00 per copy.*

Forty-two papers on nondestructive testing of nuclear reactors and components are contained in this symposium. Eddy-current, radiographic, and ultrasonic-test methods are a few of the techniques covered.

Government Publications

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound; copies available from National Advisory Committee for Aeronautics, 1512 H St. N.W., Washington 25, D. C.*

The following publication is available:

TN 3786. Handbook of Structural Stability, Part VI—Strength of Stiffened Curved Plates and Shells. By Herbert Becker; 82 pages.

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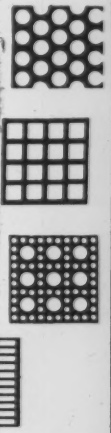

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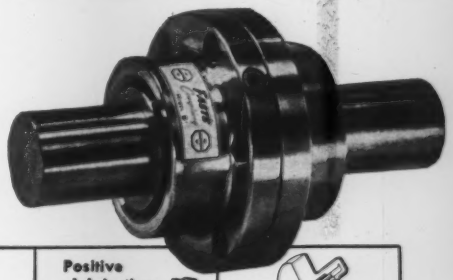

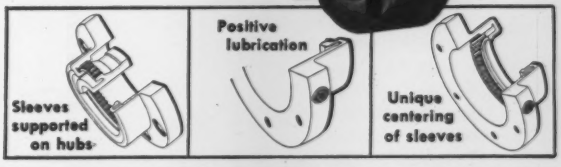

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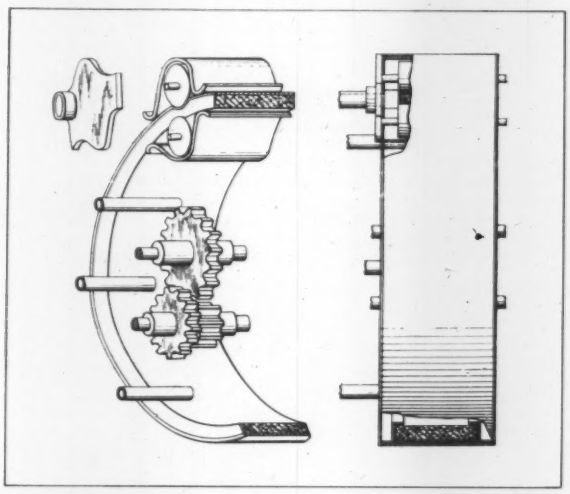
NOTEWORTHY

Patents

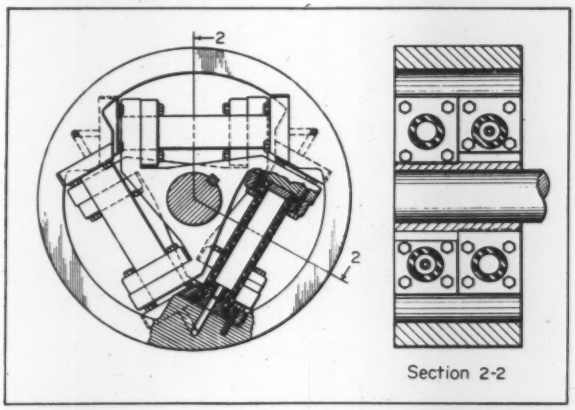
Belt-Scavenged Lubrication System

A lubricating system, not dependent on gravity, employs a recirculating, oil-absorbent belt to scavenge lubricant thrown from rotating parts. The belt passes



between rolls which wring the oil into a reservoir. From there, the oil is returned eventually, as spray, to the parts requiring lubrication. *Patent* 2,834,432 *assigned to Thompson Products Inc., Cleveland, by Norman M. Sacks.*

Shock-Absorbent Wheel



Resilient cylinders function as elastic spokes to absorb fluctuations in torque transmitted from the hub of a wheel to its rim. Each side of the wheel carries three cylinders. Each cylinder has one end closed and bolted to a flange on the triangular hub. The other

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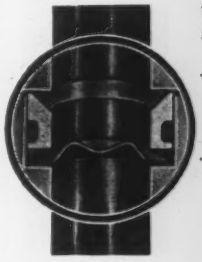

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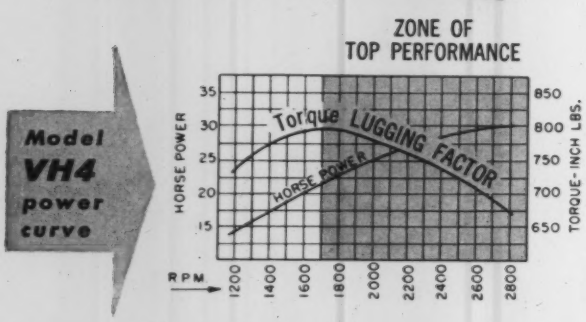

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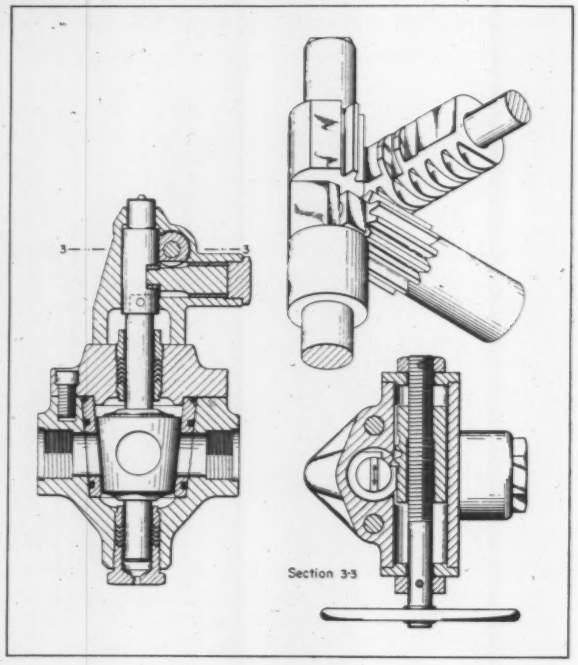
end is bolted to the wheel rim. Channels through the rim connect each cylinder with one other, displaced 60 deg, on the opposite side of the wheel. Cylinders and channels are filled with fluid. Fluctuations of transmitted torque are accommodated by equal and opposite deformations of connected cylinders and by fluid flow between them. *Patent* 2,833,131 *assigned to The Cooper-Bessemer Corp., Marion, Ohio, by Carl David Miller.*

Rotary-Linear Actuator



The outer surface of a cylinder carries two racks each of which rotates a pinion when the cylinder is translated axially by a leadscrew. One pinion rotates a shaft of which it is a part. The same shaft is translated axially a limited distance by an eccentric pin on the other pinion. Application to a valve control system is illustrated. Axial translation of the valve stem frees the plug from its seat, and rotation of the stem aligns the plug hole with the fluid flow. *Patent* 2,833,-510 *assigned to Cameron Iron Works Inc., Houston, Tex., by Herbert Allen and Ralph E. Hammond.*

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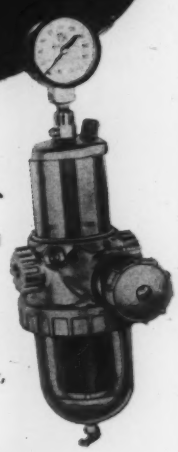

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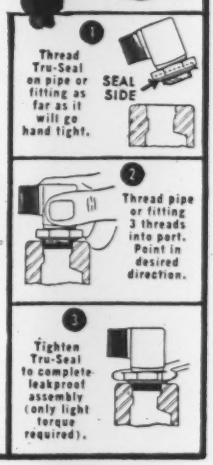
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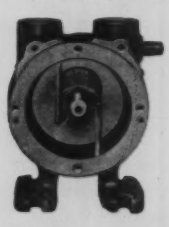

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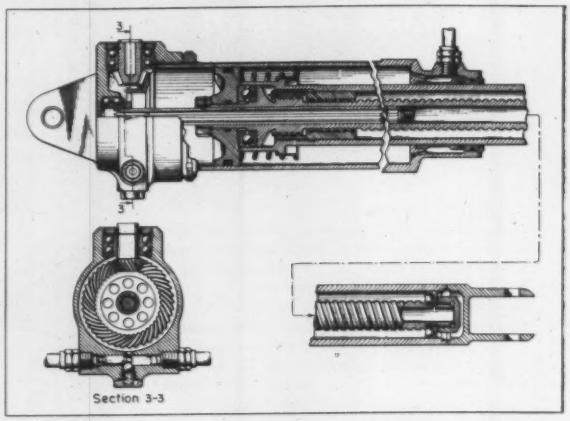
Each individual Leiman Vacuum Pump is given a long test run before shipment to assure fully rated vacuum, pressure and c.f.m. capacity.

Over half a million Leiman Vacuum Pumps have been installed with utmost satisfaction. Design Leiman dependability into *your* equipment.

WRITE for 16-page catalog, plus Application Book showing many "how-to-do-it" blueprints.

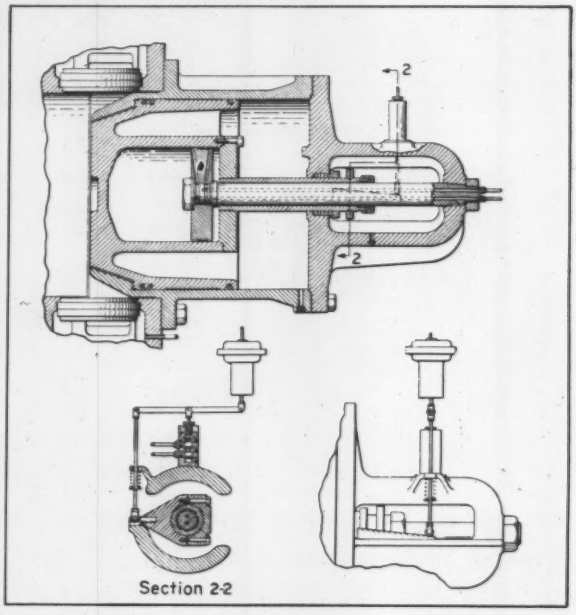
LEIMAN BROS., Inc. 158 Christie St., Newark 5, N. J.
Established 1887

LEIMAN Rotary Air and VACUUM PUMPS



the nut off its Acme threads and engages the circulating balls with their mating leadscrew groove, extending the piston rod. *Patent* 2,835,142 *assigned to Lockheed Aircraft Corp., Burbank, Calif., by Curtis W. Foster.*

Adjustable Cylinder Head



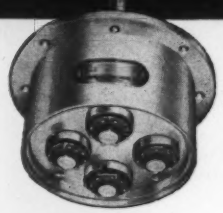
Effective volume of a cylinder is adjusted by axial movement of a piston which comprises the cylinder head. Inside the head is a small cylinder and another piston held stationary by a hollow rod fixed to the main cylinder housing. Fluid under pressure to move the cylinder head is fed to either side of the smaller piston through a two-position valve. Valve controls can be manual or automatic. *Patent* 2,833,462 *assigned to Worthington Corp., Harrison, N. J., by William Scheerer.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

One Device Detects & Controls MULTIPLE SPEEDS

• ACCURATELY • POSITIVELY • RELIABLY

SYNCROSNAP MULTI-TECTOR



covered by patents and patents pending.

Syncro-Snap MULTI-TECTOR detects and controls as many as eight separate circuits, and actuation can be accomplished on a high and low speed limit on each circuit.

For instance, inter-related speeds on automated systems can be synchronized. Machine tool speeds can be controlled as accurately as ¼ of 1%. Speeds of various components in aircraft and missiles can be sequenced or synchronized. Separate drives on equipment, such as large printing presses, can be actuated at predetermined speeds. A typical use is a four-stage MULTI-TECTOR on diesel engines which (1) cuts out cranking motor, (2) actuates cooling circuit, (3) controls fuel requirements, and (4) signals full speed and "too-low" speed.

MULTI-TECTOR measures only 5" in diameter x 4" deep. Housing is standard to provide maximum economy. Individual Syncro-Snap switches used in the MULTI-TECTOR operate on speed alone, regardless of voltage or load. They possess a life expectancy of 1.5 to 3 million cycles, with no signs of frictional wear and no variance in operating characteristics. Send requirements today for quotations.

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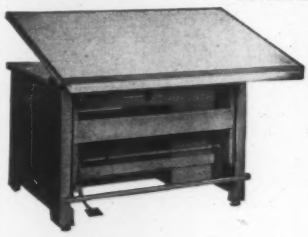

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Make sure you check with Mayline before you buy drafting room furniture and equipment. You will be so pleased with both the products and the prices that you will insist on Mayline for your source.

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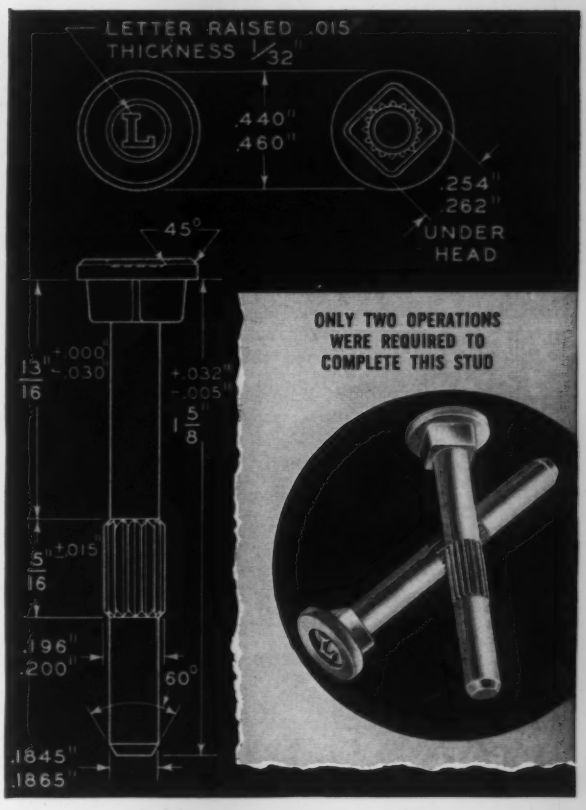
MAYLINE MAYLINE MAYLINE

Circle 513 on Page 19



skill high – cost low

by cold heading

Cold heading was the only method seriously considered for making this stud. It required exceptional skill to produce this part economically and still meet quality requirements.

By using special adapters on cold headers, Progressive evolved a low cost method for producing studs with sharp, well-defined corners and clean, rolled knurling on the stem to facilitate assembly.

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SLOTTED TAPPING SCREWS AND PHILLIPS HEAD SCREWS

THE PROGRESSIVE MFG. CO.

Division of The Torrington Company

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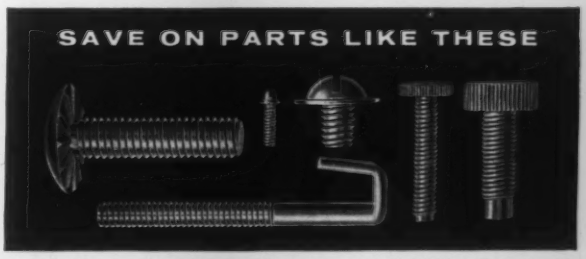

AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.

Circle 514 on Page 19

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We Can . . .

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- reduce rejects, hand adjustments or other supervisory attention
- provide you with precise gearing for any purpose whatever
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Circle 515 on Page 19

"TORQUE WRENCH" MANUAL

Sent upon request

Formulas
Applications
Engineering data
Screw torque data
Adapter problems
General principles

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ADDISON QUALITY ILLINOIS

Manufacturers of over 85% of the torque wrenches used in industry

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REGARDLESS OF YOUR NEEDS WE CAN SUPPLY THEM

Check these Advantages

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Delivery to meet your requirements.

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Circle 516 on Page 19

Increased Insulation
BETTER CONNECTIONS
JONES BARRIER
TERMINAL STRIPS

Leakage path is increased — direct shorts from frayed terminal wires prevented by bakelite barriers placed between terminals. Binder screws and terminals brass, nickel-plated. Insulation, BM 120 molded bakelite. Finest construction. Add much to equipment's effect.

Jones Means Proven Quality

No. 2-142 No. 2-142-¼ W No. 2-142-Y

Illustrated: Screw Terminals—Screw and Solder Terminals—Screw Terminal above Panel with Solder Terminal below. Every type of connection.

Six series meet every requirement: No. 140, 5-40 screws; No. 141, 6-32 screws; No. 142, 8-32 screws; No. 150, 10-32 screws; No. 151, 12-32 screws; No. 152, ¼-28 screws.

Catalog No. 21 lists complete line of Barrier Strips, and other Jones Electrical Connecting Devices. Send for your copy.

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CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
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WHAT YOU CAN DO WITH COMPACTED METAL PARTS!

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Powder metallurgy, the technique of converting metal powder into finished machine parts, has been the specialty of Compacted Metals Corporation for over 10 years.

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(Products from powdered metals)

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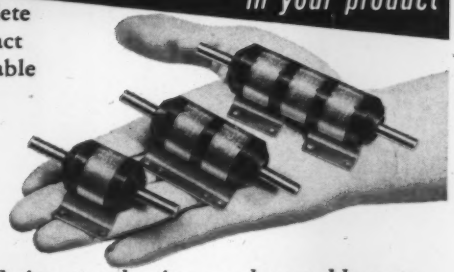
Metron MINIATURE SPEED CHANGERS ... *Ready-to-go in your product*

- Complete
- Compact
- Adaptable



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- Over 400 different standard ratios! 10:9 to 531,441:1
- Small! 1.050" diameter. Overall lengths: Class A, 3-1/8"; Class B, 3-15/16"; Class C, 4-3/4"
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Circle 520 on Page 19

FOR CONTROLLING SEALING MACHINES

PROBLEM: The Peeco Corporation of Los Angeles, California, required a foot valve that would assure SPEEDY, ACCURATE and CONSTANT control of their Heat Sealing Machines.

SOLUTION: The Model HF 3-way valve encircled above.

This rugged, non-corrosive, low-cost Airmatic Valve is available in either 3-way or 4-way models . . . hand or foot-controlled . . . locking or non-locking for the control of small cylinders . . . with or without spring return for ON or OFF positions. Its compact design and easy operation are particularly desirable to the design engineer for use with air, oil or water, 0-200 psi.

OTHER APPLICATIONS: The Model HF is also superbly suited for staking and marking operations, air chucks, air vises and air presses.

OTHER MODELS: Airmatic makes over 300 models of valves and cylinders for almost every automation control need. For complete details, write or telephone Cleveland: WOodbine 1-5320.

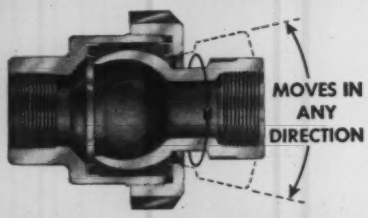
AIRMATIC VALVE, INC.

7317 Associate Ave. • Cleveland 9, Ohio

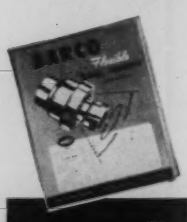
Circle 521 on Page 19

BARCO *Flexible* BALL JOINTS

—when you need movable joints in piping handling



STEAM, OIL, CHEMICALS



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- Provides for movement in piping—up to 40° side flexibility, plus 360° rotating movement.
- Stainless steel and chemically inert gaskets for strong chemicals. No metal-to-metal contact. Choice of body materials.
- One Barco Ball Joint does the work of two or more ordinary swivel joints because "it moves in any direction!"
- Many models available. For pressures to 4,500 psi; temperatures to 1000°F. 15 different sizes. ¼" to 12". *Ask for recommendations.* BARCO MFG. CO., 506J Hough St., Barrington, Illinois.

THE ONLY TRULY COMPLETE LINE OF FLEXIBLE BALL, SWIVEL, SWING AND REVOLVING JOINTS

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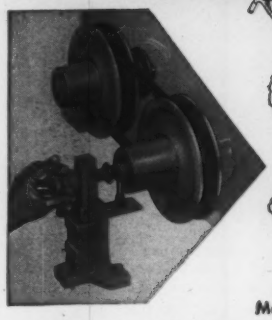
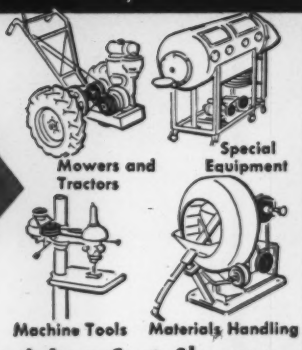
VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines





Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

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- Protect against thread damage, dust, dirt, and moisture.
- For inside and outside application. All sizes. Immediate delivery.

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

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Gentlemen: Please send samples and prices of closures in Polyethylene ☐ Aluminum ☐

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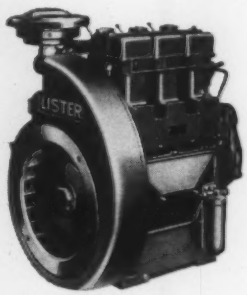

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30 BHP @ 1800 rpm

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For Primary, Auxiliary and Emergency Power

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Quick, easy installation. Readily portable. For outdoor use in any weather; indoor use even in the most restricted spaces.

Compact, air-cooled Diesel power from 3½ to 30 BHP

Readily available parts and service. Write us your requirements and for data and prices.

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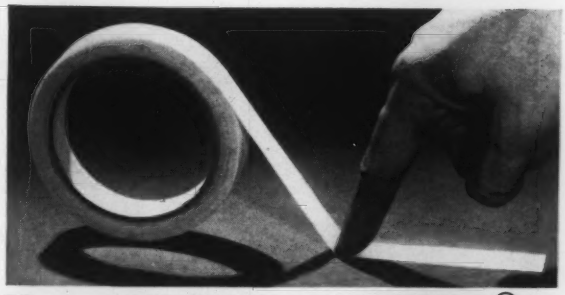

New TEMP-R-TAPE® C

.002" thick, 2750 v/m pressure sensitive TEFLON* tape For -100°F to 500°F applications

TEMP-R-TAPE® C, CHR's newest pressure-sensitive tape, is made of ultra-thin, high dielectric, cast Teflon film to which a silicone polymer adhesive has been applied. Both pressure-sensitive and thermal curing, the adhesive sticks well to any surface over a −100°F to 500°F (−70°C to 260°C) temperature range. Providing an easy-to-apply, extremely thin, high dielectric insulator (2750 volts/mil), TEMP-R-TAPE C was designed for and is now being used in the manufacture of miniature electronic units to withstand Class H and higher temperature requirements. *Send for data on TEMP-R-TAPE C and CHR's other extreme temperature, electrical and mechanical pressure-sensitive tapes.*

CONNECTICUT HARD RUBBER

NEW HAVEN 9 **CHR** CONNECTICUT

*du Pont TM.

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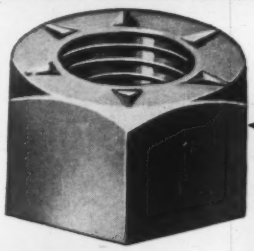
SPECIFY GRIPCO LOCK NUTS



to resist stress, wear and vibration

They increase product durability at low initial cost

Simple one piece design — no inserts — no outside devices. Nothing complicated — the Gripco locking action is within the nut itself, yet you get low initial cost and low application cost with increased customer satisfaction. Speed production and lower manufacturing costs on your products now.

Send for samples and full particulars.

Gripco Products Include:

Gripco Lock Nuts • New Gripco "Clinch Nuts" Gripco Hi-Nuts • Gripco Pilot-Projection and Countersunk Weld Nuts

all with or without the famous Gripco positive locking feature. Also Standard Semi-Finish Nuts.

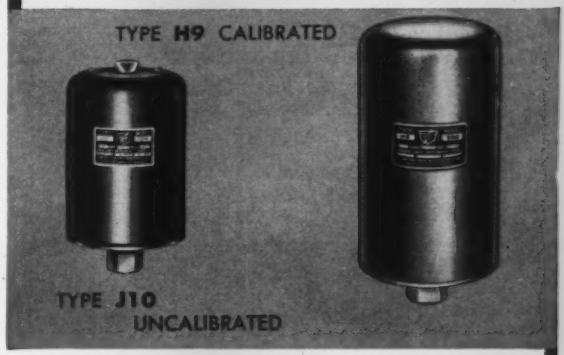
115

GRIP NUT COMPANY

103 Maple Ave. • South Whitley, Ind.

Circle 527 on Page 19

Sensitive H9 J10 PRESSURE and VACUUM CONTROLS



UNITED ELECTRIC's Type H9 and Type J10 controls are highly sensitive precision built pressure and vacuum controls designed for applications where close on-off differentials and constant repeatability are required. Type J10, being uncalibrated, is smaller and less expensive than Type H9 which is calibrated and has a knob & dial adjustment.

Specs:	
Various Ranges	H9-J10 — between 30" Hg. Vac. and 15 P.S.I.
Switch Differentials	H9 — ½ to 1 ±1/10" W.C. depending upon model. J10 — ¾ to 1 ±3/10" W.C. depending upon model.
Switch Ratings	Standardly 3 amps 115/230 A.C.
Switch Types	N.O., N.C., or Double throw, no neutral position.
Electrical Connections	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections	One ¼" NPT pressure connection.
Size	H9 — 7" x 3⅜" dia. J10 — 6⅛" x 3⅜" dia.
Approximate Weight	H9 — 3 lbs. J10 — 2¾ lbs.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Write for complete specification and pricing data on the Types H9 and J10. Similar data available on all other UE controls.*

United Electric Controls COMPANY

85 SCHOOL STREET WATERTOWN MASS

Circle 528 on Page 19

EASTMAN FLUID POWER LINES

Designed and Developed by ENGINEERS for ENGINEERS

Only Eastman can give you the above Split Flange with the advantages of Eastman's exclusive "Inter-Lock" Clamp:

1 **"Inter-Lock" Clamp for Best Hose Connection** — Accurate machining assures alternate positioning of ribs of clamp and barbs of insert—**avoids pinching and weakening of hose**—creating exclusive Eastman Inter-Lock grip.

2 **Split Flange for Tighter Seal at High Pressures**—Cuts production and replacement costs with a No-Thread, No-Leak "O" Ring Connection which eliminates threads, sealing compounds, spiral leaks and housing distortion.

Permanently Attached Flanged Head Couplings: ¼" thru 2" 375 to 5000 p.s.i.

Clamp Type Coupling with Split Flange Stems: ¼" thru 2" 375 to 5000 p.s.i.

Write for Eastman Inter-Lock Clamp Bulletin No. 40.

Rely on Eastman for quality—first to be specified by America's leading OEM's.

Eastman
MANUFACTURING COMPANY
Dept. MD-8A, Manitowoc, Wisconsin

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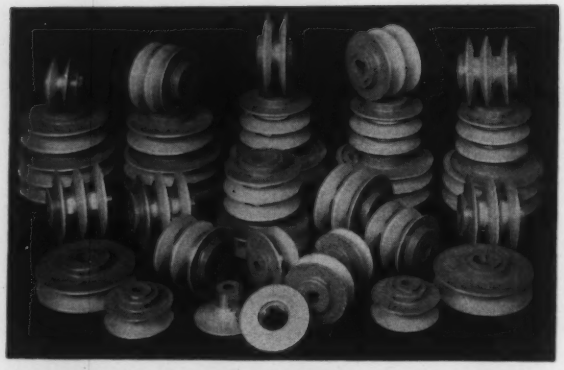

BROWNING VARIABLE PITCH SHEAVES

Browning offers the most complete line of FHP sheaves, including 108 variable pitch sizes and types, single and double groove. All are accurately balanced, true running, easily adjusted. With fixed bore or the same *malleable* split taper bushing used in Browning sprockets, couplings, paper pulleys, and other sheaves. Made by experts in power transmission since 1886—Browning Manufacturing Company, Maysville, Kentucky.

Ask your Browning distributor or write us for Catalog V147.

Browning POWER TRANSMISSION EQUIPMENT

Circle 530 on Page 19

The A. K. ALLEN CO., 255 East 2nd St., Mineola, N. Y.

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Company.....

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MD-8-V

Circle 531 on Page 19

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NEW MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝" . . . width—1 13/16" . . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept A30-828.

AGA ELASTIC STOP NUT CORPORATION OF AMERICA

1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in pneumatic timing

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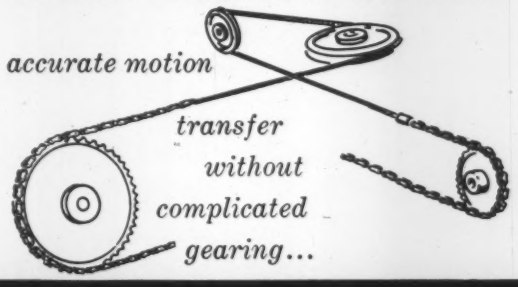

SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

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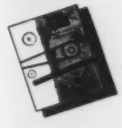

Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

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Sierra ENGINEERING CO.

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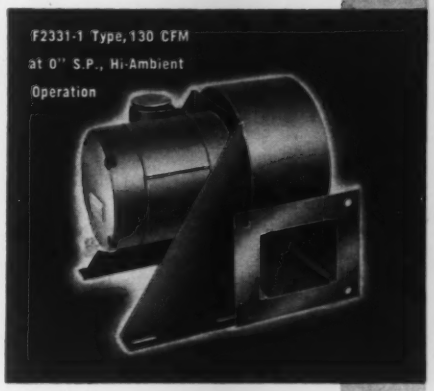
Circle 533 on Page 19

RELIABILITY *must* START ON THE GROUND



Missile launching equipment manufacturers must be positive of every component in their vital equipment. For this reason, Air-Marine blowers are specified equipment in many of the launching beds built today. The blower shown here is currently being used in the Army's NIKE Hercules Program. Interested manufacturers are urged to look into the proven reliability of Air-Marine's complete selection of sub-fractional H.P. Motors, Blowers and Fans.

air · marine motors, inc.

AMITYVILLE, NEW YORK

LOS ANGELES, CALIF.

See us at Booths 1612, 1613 WESCON SHOW.

AIR-MARINE MOTORS, INC.

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FREE...
"Diamond H"

"Check List"
OF
Relays, Thermostats, Switches
FOR

Air conditioning, aircraft, appliances, automation, electronics, guided missiles, machine tools, panel boards, heater circuits, motor control, etc.

Yours for the asking.

THE **HART** MANUFACTURING COMPANY
118 Bartholomew Ave., Hartford 1, Conn.
Phone Jackson 5-3491

Circle 535 on Page 19

ENGINEERS
AVAILABLE OR WANTED

AVAILABLE: Senior Mechanical Design Engineer for board work. High grade draftsmanship on assemblies. Superior ability on design of machinery, product, power press dies, production tools. Originality and ingenuity on new developments. Any location and length of engagement. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

WANTED: PACKAGING EQUIPMENT MAN. Age 25-35. High School or College Graduate. Some experience in packaging or overwrapping equipment such as found in Textile, Food and Meat Industries. Some travel. Willing to relocate if necessary. Good starting salary. Incentive Plan. All expenses paid. Reply in confidence. Box 233, Simpsonville, South Carolina.

VIGILANCE

The final victory over cancer will come from the research laboratory.

But there is a more immediate victory at hand today. Many cancers can be cured when detected early and treated promptly. *Vigilance* is the key to this victory.

There are certain signs which might mean cancer. Vigilance in heeding these danger signals could mean victory over cancer for you:

1. Unusual bleeding or discharge.
2. A lump or thickening in the breast or elsewhere.
3. A sore that does not heal.
4. Change in bowel or bladder habits.
5. Hoarseness or cough.
6. Indigestion or difficulty in swallowing.
7. Change in a wart or mole.

If your signal lasts longer than two weeks, go to your doctor to learn if it means cancer.

AMERICAN CANCER SOCIETY

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MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE, EDWARD F. CLANCY
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
CHARLES F. REINER
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....1106 Pine Valley Rd.
FRED J. ALLEN
Griffin 7854

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND

Dallas 35 .....Exchange Park Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Caxton St., Westminster

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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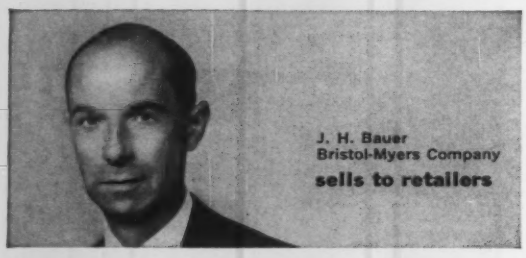
BPA NBP

Does specialized business publication advertising help salesmen?

No one is in a better position to give a hard-boiled, practical answer to this question than the men who spend their working lives on the sales front...the men the ads are supposed to help... the men who sell.

Here are the statements of salesmen who know what advertising does for them when it appears in the industrial, trade or professional publications that serve the specialized markets to which they sell:



says Mr. Bauer: "My end of the business is primarily to do things for the retailers. So's the trade journal side of our advertising program.

"The consumer advertising gets people to go to the retailers and gives us good brand recognition and all that, but everything else we do in this company is to help the retailers move our products and make a profit.

"A big part of that is persuading them to get our brands out where they can be seen to meet the advertising effect.

"We have more than trebled the number of salesmen compared to what we had several years ago but our distribution has expanded so greatly that it's still hard to cover the trade.

"Thank goodness our company does a very stout trade advertising job for us. It supplements our heavy consumer advertising.

"It works too. It breaks the ice. No matter where I walk in to call on a wholesaler or retailer, I'm no stranger.

"I know that some companies in our field operate under the false assumption that consumer advertising can do it all.

"It can't.

"The consumer advertising can't talk about how we can help the retailer make money. You can't count on it alone to sell the executives of chains.

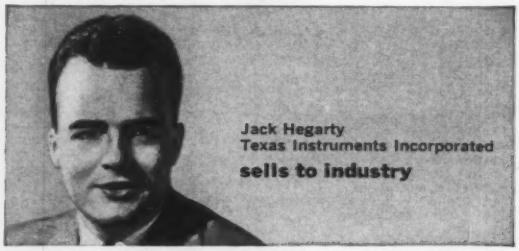
"Our trade advertising makes druggists, grocers and variety store people conscious of a new product, or a new promotion, or a new deal. Does it before I get there, too. It makes them anxious about it before I get there. It lets them know there's something big coming.

"Our advertising in the business papers also impresses retailers about the business they could lose if they let their stocks dwindle.

"Now, there's another side of our business paper advertising that has a very strong influence on my sales. I mean it really helps me. I'm talking about the advertising to professional people. That advertising does a lot to persuade nurses and doctors to recommend our products to patients under their care. Bufferin, for example. Naturally, it's wonderful for my end of the business if that advertising creates the impression with thousands of patients that our products have achieved professional recognition. I actually talk to retailers about what our company is doing to win the recognition of professional people and induce them to recommend our products.

"Incidentally, that is surely one area of business paper advertising where the consumer ads can't reach. Only in professional journals can you talk in detail of ingredients, for example, which can be a very important part of our sales story.

"It's pretty obvious that trade advertising which does all these things helps me sell."



says Mr. Hegarty: "I sell semiconductors and other components to original equipment manufacturers in the electronics field. With the tremendous expansion in the electronic industry today, one of our problems is prompt coverage of the market when a new or improved device is announced. I can contact all my larger accounts within a few days, but it takes considerable time to cover the many smaller accounts.

"That's one of the reasons I think our advertising in business publications is so important. It covers all my prospects, large and small, and gets the story of our products to all three groups that can influence purchases – the engineers, the purchasing agents and top management. In some accounts 50 or 60 engineers will

attend a meeting. However, there are still many decision-making personnel who can't attend because of other demands on their time. But I know that they will get our story from our advertising.

"On cold calls, many times my selling effort is greatly assisted by the 'pre-selling' of our advertising and it seems to me that advertising often gets me an entree at a higher level than I can usually get on cold calls.

"It helps in other ways, too. For instance, we get inquiries for applications and devices that haven't been developed by our company. Prospects read the advertising, get clues, then contact us. In one case we ran an ad that basically showed a specification sheet on a new component. On one inquiry I followed up, the engineer had the magazine open on his desk right at our ad. He asked me, 'Can you meet this spec?' It was different – but, by some specialized design work, something we could do. I secured a first release order for over $70,000 just from this one inquiry.

"While my division of our corporation had first established its name in the industry on the basis of its work in semiconductors, we also manufacture many other components. They are in competition with units of companies longer established than we are. Here our advertising helps establish our name as a progressive company with a dependable reputation, good to deal with."

says Mr. Beach: "We have to sell our product first to the wholesaler; then help him sell to the retailer. We do a lot of missionary work. We make calls with the wholesaler salesmen and we run dealer and clerk training clinics in which we try to help the dealers improve their merchandising.

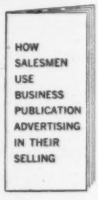
"Our trade advertising in publications read by the wholesaler and dealer, works with us along those same lines. In other words, it's like having an additional sales representative in each territory constantly calling on the dealers and wholesalers. Every time they open their trade books he tells them about our products and the special promotions we run to help them sell more. He works nights too, and calls on them at home when they're doing their reference work and planning. I know they do take their magazines home at night and read them. So, in effect, this 'salesman' works at night for us, and I do believe he finds them in a more receptive mood at that time.

"The greatest evidence that our advertising is out there doing a job and really paying off is in connection with the two large-scale promotions we do each year.

"For instance, right now we're working on our current Christmas promotion called 'The Bell-Ringer'. That was announced in September. Between the announcement and the Christmas selling season we must sell the wholesaler and then set up a schedule with each wholesaler to go out with his men and call on the trade and actually sell the deal to the retailer. You can imagine how tight our schedule is. In this short span of time we have to call on practically every hardware dealer in the territory. It adds up to a terrific number of calls and in order to get around, we just can't afford to give each dealer all the time we'd like to. In addition, it's extremely difficult to explain all the details on something like this Christmas promotion in the short time allotted each dealer.

"We couldn't do it if the advertising wasn't in there doing part of the work for us. Believe me, it's wonderful to find that when you do call on a wholesaler or dealer you don't have to take the time to explain all the details, because he has already read about it in the hardware publications. In most cases he's ready to see the merchandise. We have the opportunity to close the sale in short order. Right now I'm engaged in making dealer calls with wholesalers' salesmen and I'd say that nine cases out of ten the dealers have already seen our ads on the Christmas promotion and are somewhat pre-sold on the deal. In fact, in most cases I've found that all I have to do is show him the merchandise."

ask your own salesmen **what your company's business publication advertising does for them. If their answers are generally favorable, you can be sure that it is really helping them sell. If too many answers are negative, it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.**



How salesmen use their companies' advertising to get more business

Here's a useful package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' business publication advertising.

You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy.

National Business Publications, Inc.

NBP

...each of which serves a specialized market in a specific industry, trade or profession.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 9C, 1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Business Publication Advertising in Their Selling."

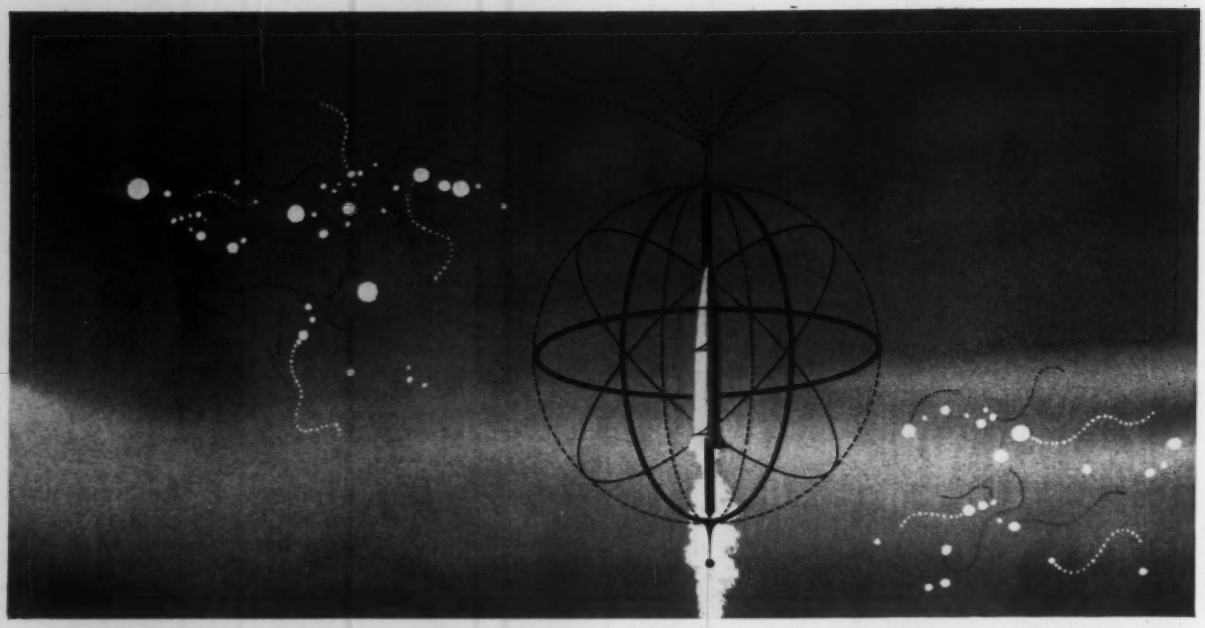
Name _____

Title _____

Company _____

Street Address _____

City _____ Zone _____ State _____



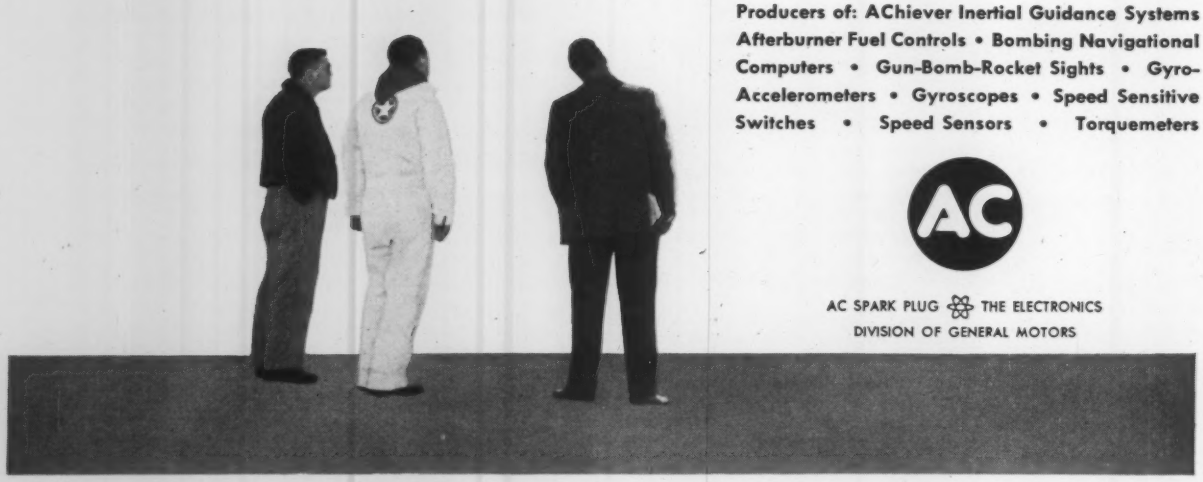
AIMING FOR THE STARS!

You'll be able to aim missiles at the stars . . . and hit your target . . . with AC's incredibly accurate Inertial Guidance Systems. And we're aiming for top-flight engineers to do the job . . . men who want to see their stars rise in the exciting electronics firmament.

This is opportunity. For at AC you can exploit your full talents on guidance systems . . . or any one of a dozen other fascinating and complex electro-mechanical, optical or infra-red devices that are now in the research and development stage or in production.

There's a bright and secure future for you with AC . . . and General Motors. You can grow with one of the most rapidly expanding industries, within an organization long known for its sound policies and enlightened interest in potential leaders.

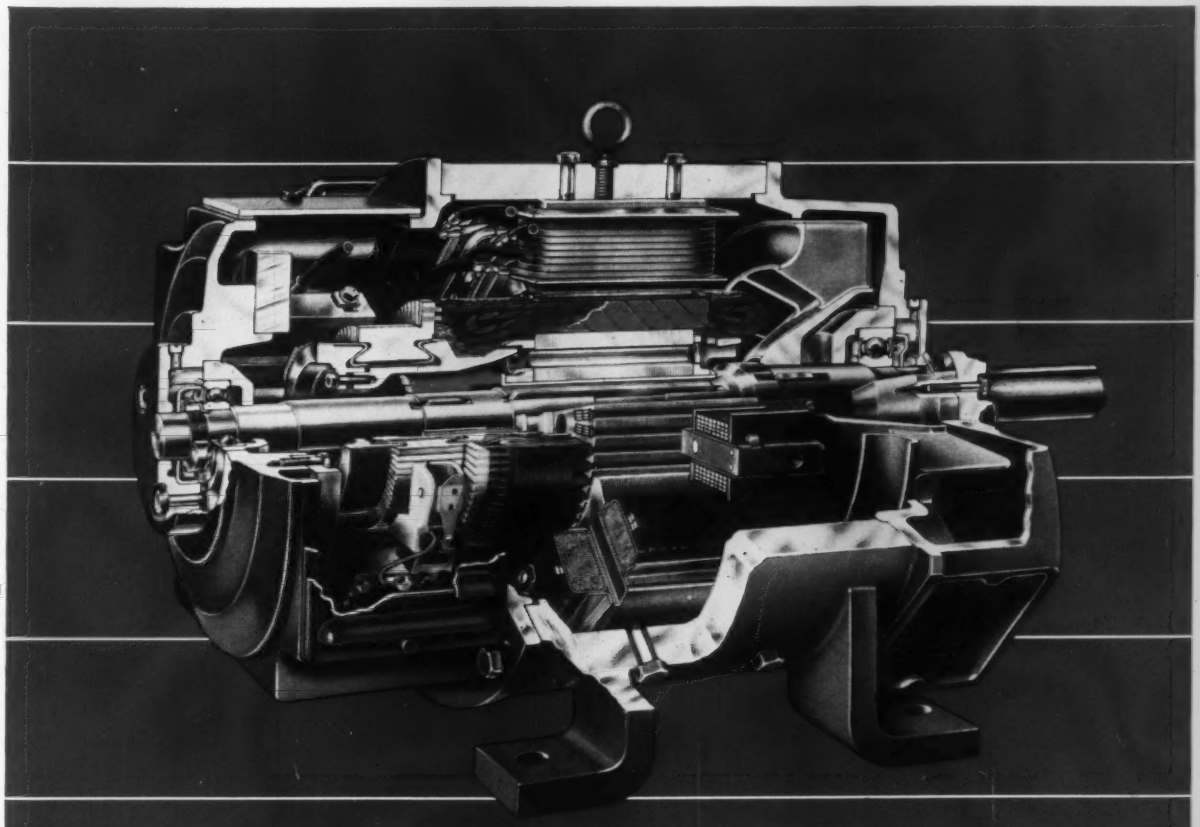
If you are a graduate engineer or physicist with three to ten years technical experience in micro-wave techniques, electronics, the electrical or mechanical fields, or in gyroscope design, you should talk with the people at AC. Just write the Supervisor of Technical Employment: Mr. C. E. Sundeen, Dept. C, 1925 E. Kenilworth, Milwaukee 1, Wisconsin; or Mr. M. Levett, Dept. C, 1300 N. Dort Highway, Flint, Michigan.



Producers of: AChiever Inertial Guidance Systems • Afterburner Fuel Controls • Bombing Navigational Computers • Gun-Bomb-Rocket Sights • Gyro-Accelerometers • Gyroscopes • Speed Sensitive Switches • Speed Sensors • Torquemeters

AC

AC SPARK PLUG THE ELECTRONICS DIVISION OF GENERAL MOTORS



THE RELIANCE SUPER 'T'

A New Kind of D-c. Motor With DYNAMIC RESPONSE

Here is a motor built to make maximum use of d-c. flexibility. The Super 'T' puts Dynamic Response into starts, stops, and speed changes. Dynamic Response gives you a 50% increase in torque and a 50% decrease in reaction time.

This top performance is due to advanced, balanced design. Lighter, small diameter armatures cut mechanical inertia 50%. Superior Class B insulation gives extended life even at temperatures as great as 130° C.

Top grade insulation plus engineered ventilation lets the Super 'T' take tremendous overloads. In fact, the Super 'T' can develop double normal horsepower during starts, stops, and speed changes.

The Super 'T' is a compact power package, designed inside and out for tough industrial service. From appearance to performance, the Reliance Super 'T' with Dynamic Response is today's most modern industrial motor.

C-1577

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 288A CLEVELAND 17, OHIO
CANADIAN DIVISION: TORONTO, ONTARIO
Sales Offices and Distributors in principal cities

Circle 402 on Page 19

How to squeeze more production from your automatic forging equipment

...at no extra cost

AUTOMATIC forging machines are no better than the uniformity of the steel you process. When structural or chemical changes occur in the steel you're using you have to interrupt operations to adjust your equipment. And you lose the continuous production you paid for!

You can avoid these interruptions by using uniform steel. Timken® electric furnace fine alloy steel, for instance. It's uniform from bar to bar, heat to heat, order to order.

We take many extra quality-control steps to make sure it's uniform—many of them were American steel industry "firsts". For example, our magnetic stirrer for molten steel assures equal distribution of alloys, uniform temperature and working of the slag. A direct-reading spectrometer insures exactly correct composition to the very moment a heat is tapped. And individual order-handling assures uniformity that meets your own end-use requirements.

You'll squeeze the most production from your automatic forging equipment, at no extra cost, by specifying Timken fine alloy steel. You'll get uniform steel and faster, continuous production. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

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